SPE JOURNAL

VOL. 16, NO. 10 • OCTOBER 1960

The Official Publication of the Society of Plastics Engineers, Inc.

IMPROVED RESIN-FIBER LAMINATES

— page 1123

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PRECISE CONTROL OF EXTRUDER BARREL TEMPERATURES — 1111

NEWEST TEST METHODS FOR VINYL PLASTICS — 1129

REGIONAL TECHNICAL CONFERENCES

Blow Molding Comes of Age — 1107

Automation in Injection and Compression Molding — 1105

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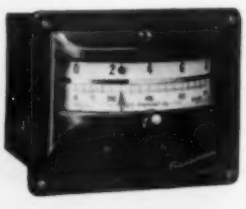

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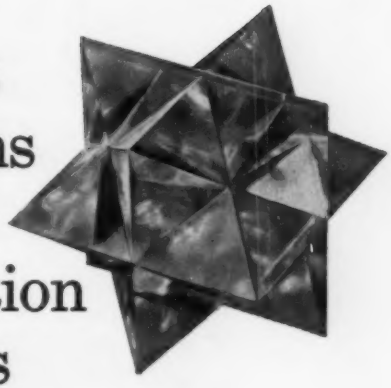
The Cover

A potpourri of new technical developments is featured on this month's cover. For more ideas, scan the Contents, above.

Prompt solutions to your production puzzlers



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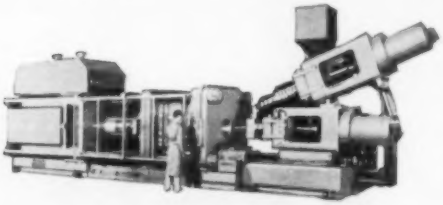

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EDITORIAL

The Mixed Blessings of Progress

Last month, during the American Chemical Society meeting in New York, much progress was reported in many scientific fields, including the field of technical literature documentation. One panel discussion, which the writer attended, covered the question "Can primary journals handle the publication of scientific literature in the face of the growing volume of research and the increasing costs of publication?" Comments on the question, generally, were in the affirmative, with certain qualifications, such as one proposal to assess contributing authors or their companies a unit page cost. Such a subsidy would be a mixed blessing.

Perhaps the greatest impact on the scientific community will be felt when the machine or computer age reaches full maturity in this field of literature documentation. The thinking is that technical literature will be divided into two main categories: (1) Technical news magazines, containing information of temporary value, and (2) Information of permanent reference or "retrieval" value. In its most highly developed form, information with retrieval value will bypass the usual publication in magazine form and be placed on magnetic tape, or other memory devices, to be filed and indexed by electronic computer. When information on a specific subject is to be retrieved, the appropriate information would be fed to the computer and all the information on that subject would then be made available to the researcher. There are researchers who won't miss the long, drawn-out searches of the literature. But there are also those who will view such progress with mixed blessings. One chemist, for example, remarked that one of his greatest pleasures is to just browse through the technical literature, especially magazines and journals not directly related to his own technical specialty. He has been rewarded many times by happening upon ideas or principles which were applicable to solving problems in his own field.

There are changes now taking place in the field of literature documentation. There always have been. Just when the browsing age will leave us and the machine age will begin, no one really knows. Only one thing is definite: When thinking about the future of this field, or any other field, it is difficult to say where informed foresight becomes outright speculation.

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Property Highlights of BAKELITE TMD-2100

All properties determined by ASTM methods on ⅛-inch specimens cut from injection molded plaques.

	Typical Property Values		
	—40°C	23°C	60°C
Tensile strength, lb./sq. in.	4800	3200	2100
Elongation in Tension, %	22	44	58
Mod. Elast. in Tens., lb./sq. in.	302,000	245,000	200,000
Flexural Yield, lb./sq. in.	13,250	6,300	3,700
Mod. Elast. in Flex., lb./sq. in	360,000	290,000	195,000
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Research Duplication

Plastics Institute Committee survey shows that plastics companies believe there is considerable duplication of research effort, particularly in such areas as relation of chemical structure and physical properties. Analysis of the survey indicates that all of the information now being developed in the large number of laboratories (more than 100 are represented among the respondents to the survey alone) could be obtained in possibly 10% of them.

Cross-Linking Polyesters

A new method of cross-linking polyesters results in a product which has remarkable adhesion to glass. The new method involves first making a soluble poly (ester-acetal) by reacting dimethyl terephthalate, the dimethyl ester of 3,9-bis(7-carboxyheptyl)-2,4,8,10-tetraoxaspiro [5.5] undecane, and ethylene glycol under alkaline conditions. Addition of a catalyst, such as the oxides of lead or zinc cross-links the polymer.

Off to Russia

A U.S. Plastics Exhibit will be off to Moscow later this month. Sponsored by the U.S. Information Agency (USIA), the exhibit is now in final stages of preparation at various parts of the country. Here's a sampling of what the Russians will see: Plastics in science and industry, plastics in the home, plastics in recreation, plastics in the arts, and plastics 1970, a projection of future uses.

Blow Molding Conference

The Newark Section of the Society will sponsor a Regional Technical Conference on Blow Molding on November 18 (see page 1107). Among the topics to be discussed: Color for blow molding, Effects of resin type on processing conditions, and applications and markets.

Improved Extruders

A system of controlling heater wattage on extruder barrels results in closer control of barrel temperatures. In some cases variation was held to an average of 1°F (page 1111). The system is available as an extra on new equipment, or machines already in the field can be modified to include it.

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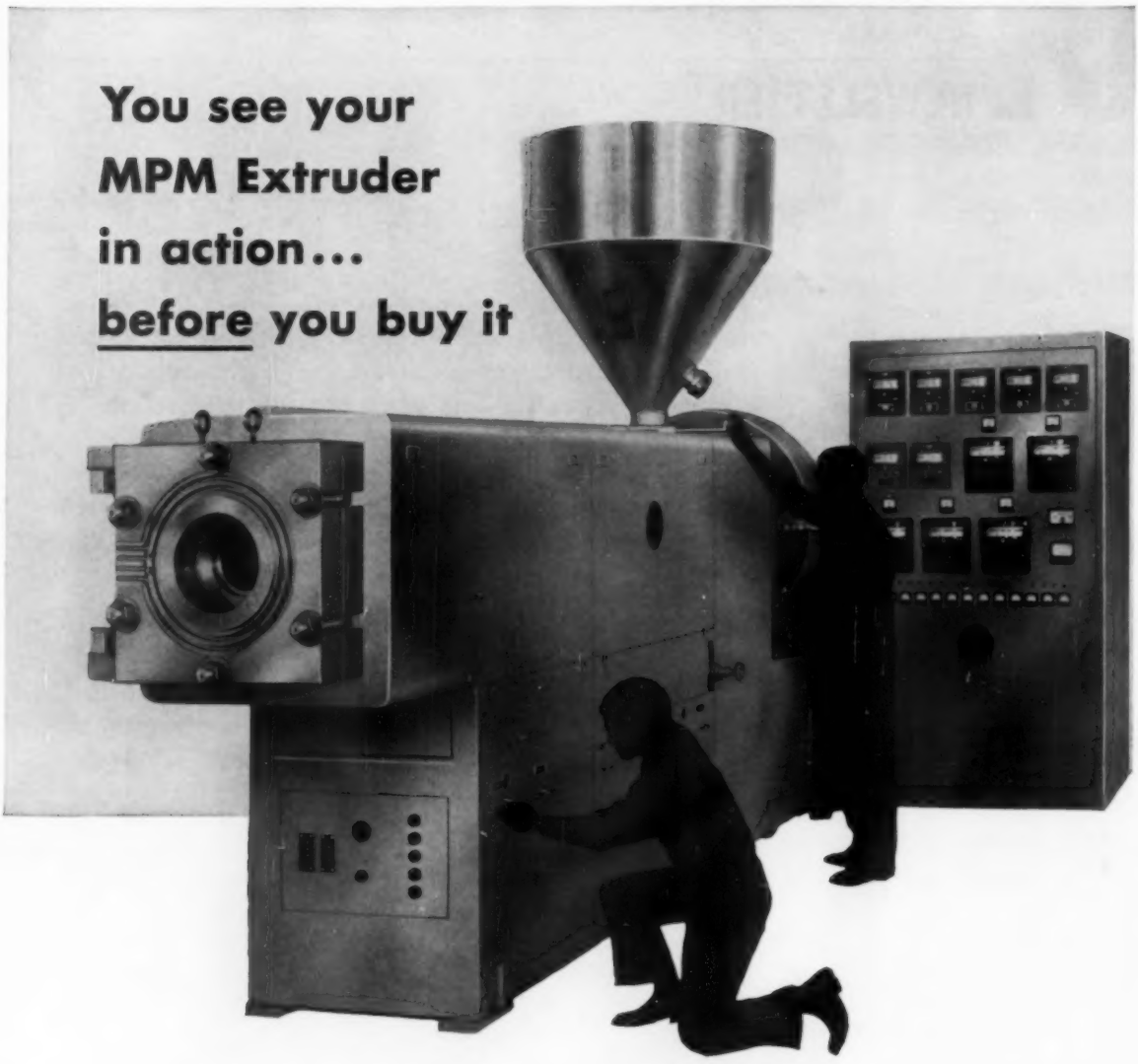
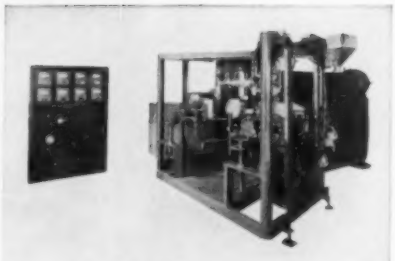


MPM doesn't sell merely extruders — it sells *production*. When you order an MPM extruder, you know exactly what caliber of performance you can expect, because you've seen it perform . . . had a chance to test every part before purchase.

Moreover, many extruders today are "patch-quilt" affairs: one piece made by this company, a second part by that, a third by still another. Not with MPM. For MPM manufactures virtually all its own components: grinds its own screws, assembles its own controls . . . all precision-built to MPM standards in MPM's, modern 90,000 sq. ft. plant.

Screw diameters available range from 1 to 12", in vented or non-vented design, and in L/D ratios of 20:1, 24:1 or longer. Either resistance-band heaters, cast-in heaters or induction heating can be specified. Extra heavy-duty thrust bearings, Xaloy-lined barrels, and precision-ground screws are typical of rugged MPM components. In short, MPM extruders are tailored for your specific needs, then proved out to you before you buy. More information? Just write Modern Plastic Machinery Corporation, 64 Lakeview Avenue, Clifton, N. J.



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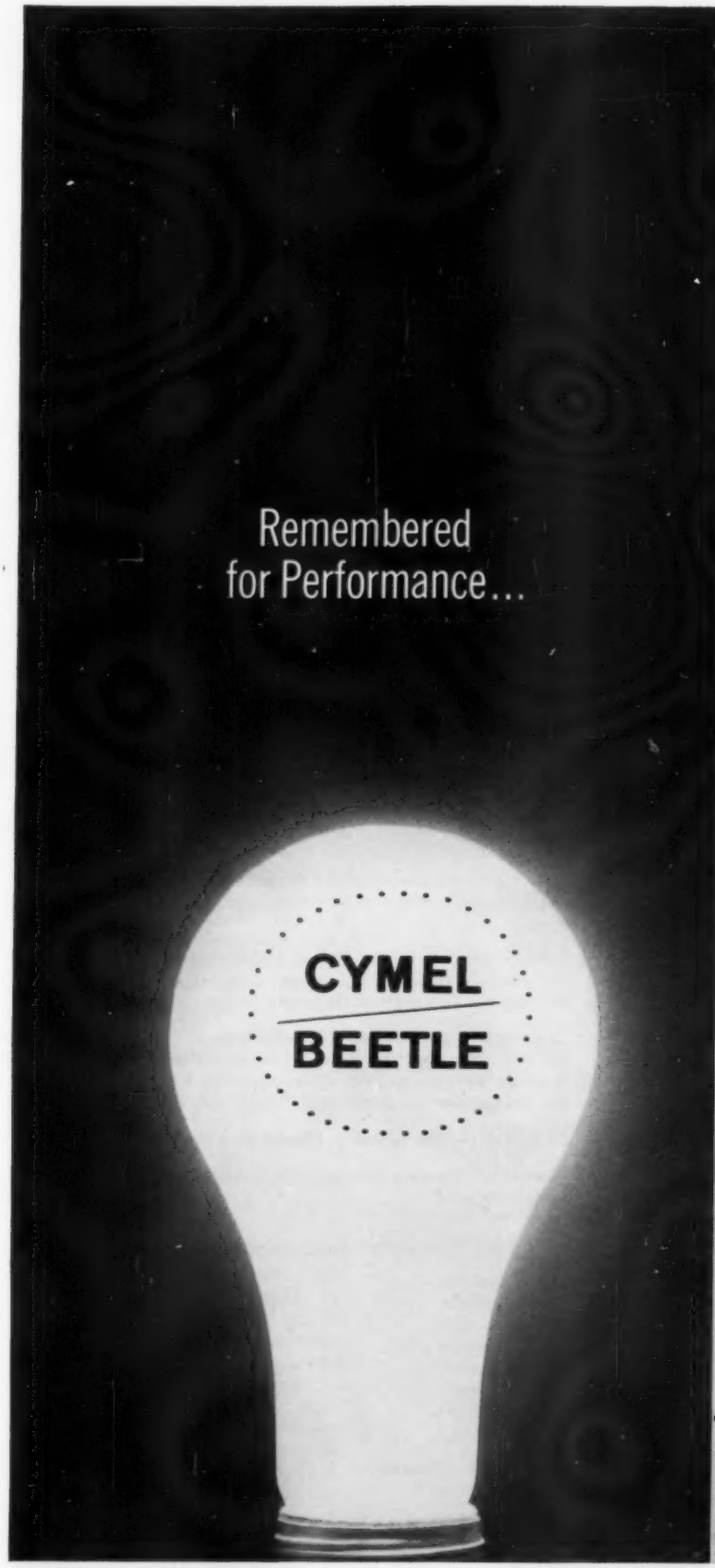

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BEETLE® UREA (alpha-filled) Additional distinctive properties: Economy of fabrication, economy of material, myriad translucent and opaque colors. Typical applications: wiring devices, home circuit breakers, tube bases, appliance housings. Specifications: Federal L-P-406A, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM), SP1 SPEC NO. 27026.

WRITE FOR COMPLETE TECHNICAL DATA.

CYANAMID

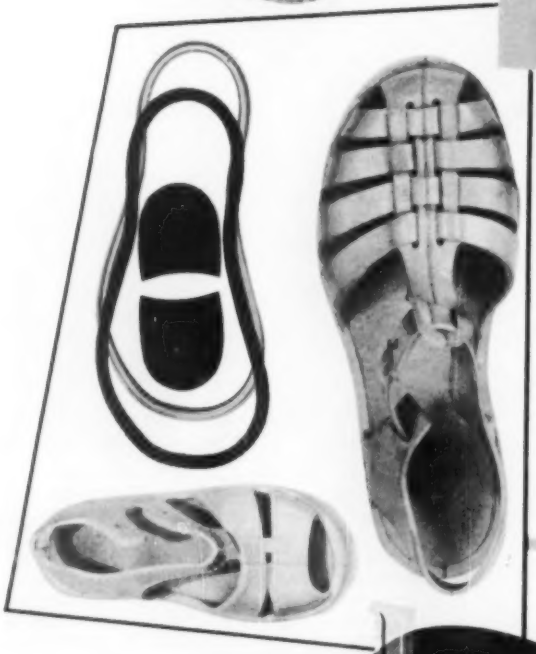
AMERICAN CYANAMID COMPANY • PLASTICS AND RESINS DIVISION • 30 ROCKEFELLER PLAZA—NEW YORK 20, N. Y. OFFICES IN: BOSTON • CHARLOTTE CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DETROIT LOS ANGELES • MINNEAPOLIS • NEW YORK • OAKLAND PHILADELPHIA • ST. LOUIS • SEATTLE • IN CANADA: CYANAMID OF CANADA LTD., MONTREAL AND TORONTO.

BLACAR®

UNSURPASSED
in Vinyl Footwear Applications

for

- Improved Processing Qualities
- Enhanced Customer Appeal



Cary BLACAR is ideally suited for practically all footwear applications: welting—soles—heels—even to complete shoes.

BLACAR vinyl has top processing qualities in both high or low pressure molding applications, offering rapid molding cycles, excellent finish and increased yield.

To enhance consumer appeal and satisfaction—use BLACAR—the vinyl that provides maximum resistance to abrasion and cracking, while imparting highly desired leather-like qualities of "tough suppleness".

BLACAR — the Quality Name in Vinyl.

Literature—Working Samples—Technical Assistance —upon request!

CARY CHEMICALS INC.

Mail Address: PO BOX 38 EAST BRUNSWICK, N. J.

Plants at: East Brunswick, N. J., Flemington, N. J., Woodside, L. I., N. Y.

VINYL COPOLYMERS—VINYL RESINS—VINYL COMPOUNDS—SPECIALTY WAXES—HIGH MELTING POINT SYNTHETIC WAXES.

SPE JOURNAL Reports from . . .

The Eastern New England RETEC

Interest in vinyl plastics high as over 350 hear of applications in footwear industry, wire and cable, and toy manufacturing

No "Breaking-In" Here

Children's overshoes, made of poly (vinyl chloride), with molded-in prestitched liners may be in production in about eight months. Liner and last are hooked in the mold and PVC injection molded over it. Also of interest: Outersoles complete with heels in various irons of thickness are being injection molded with PVC compounds and dry blends. The days when shiny new leather shoes have to be broken-in may soon be gone.

Blow Molding and Vinyls

Considerable experimental work is being directed to the blow molding of vinyl compounds. One big market the vinyl manufacturers would like to capture is the detergent container business—now dominated by high density polyethylene. Those in the business say bugs in the blow molding process, and not the material, is the factor for slow progress. Another blow molding note: The future of rotational molding with plastisols may be limited by blow molding, though not for those products having great detail.

Plasticizer Structure Related to Plastisol Fusion

P. R. Graham and J. R. Darby of Monsanto Chemical Co. described a method for relating the specific structures of plasticizers to the fusion rates of plastisols. The method involves determination of the clear point of the plastisol on a melting point apparatus. These data are then related to actual physical property measurements taken on plastisols exposed to elevated temperatures for selected time increments. Conclusions: Aromatic groups in plasticizers add to the fusion power of the compounds.

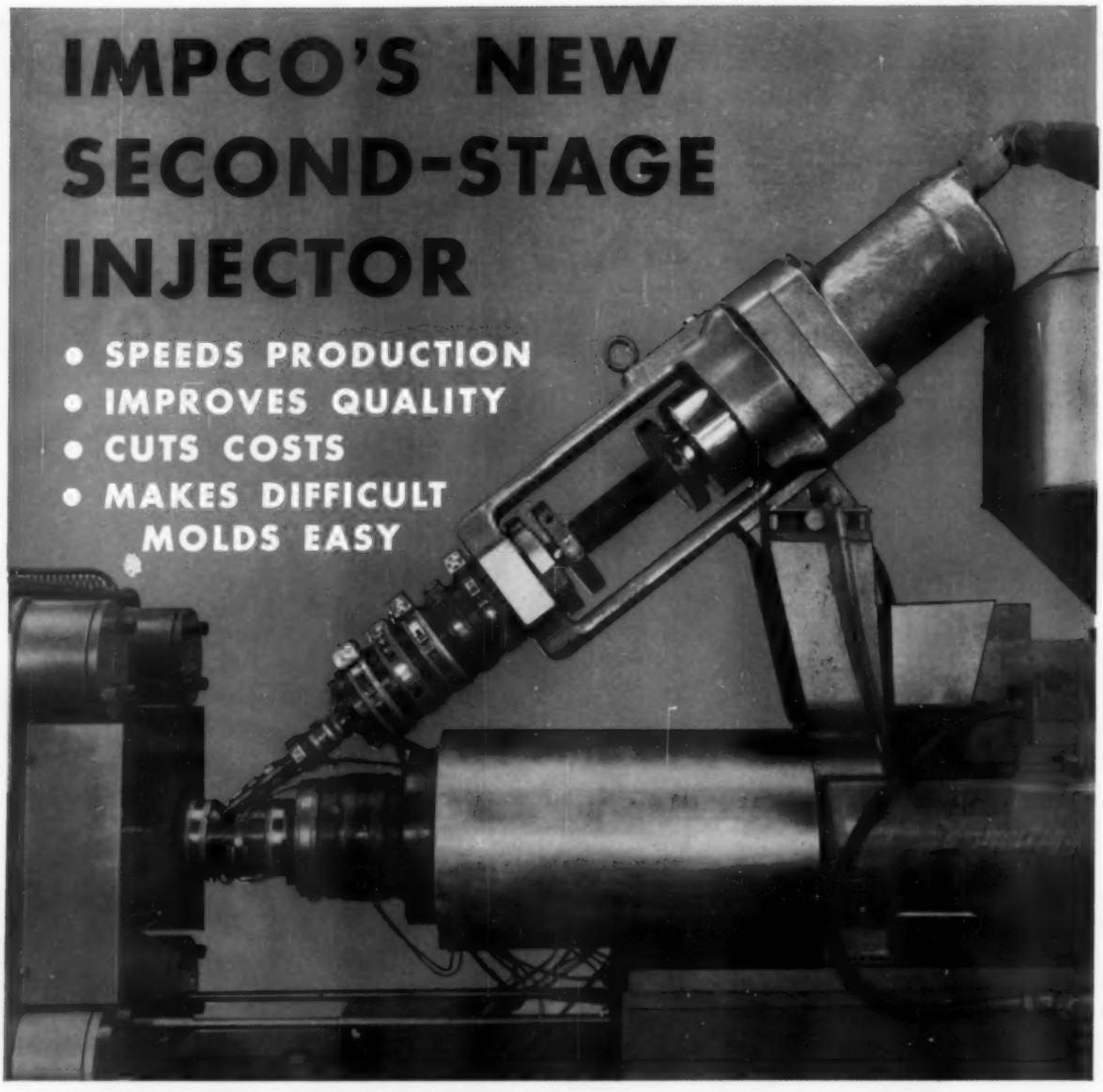
Conductive Vinyl Speeds Wire Production

Copper braiding for audio shielding was slowing up production of insulated wire and cable. Answer to the problem? A PVC braided shield, as efficient as the copper one and also possessing the same processing properties as the compound having no conductance modifiers. The material, developed by Abbey Plastics, has been extruded, tubed, injection molded, compression molded, calendered, and even roller or spreader coated. Uses are in audio cable, gasketing where grounding is important, waterproof cables, and auto ignition wire.

Fielders' Choice

The furniture and automotive industries, two of the largest users of foams, have their choice of three main materials—vinyl, latex, and urethane foams. Each is being used because of specific properties although there is a major shift over to urethane foam because of a definite price advantage.

IMPCO'S NEW SECOND-STAGE INJECTOR



The Second Stage Injector was designed to increase the effective operation of any Impco Injection Molding Machine now in service. It is also now available as standard equipment on new Impco machines. Its use gives you:

- Raw material savings
- Increased capacity
- Reduced molding pressures
- Increased mold area
- Simplified nylon molding
- Fewer rejects

Ask for Bulletin P-127 for more information.

IMPCO®

IMPROVED MACHINERY INC.
NASHUA, NEW HAMPSHIRE

MANUFACTURERS OF IMPCO PLASTIC MOLDING MACHINES

U.S.I. POLYETHYLENE NEWS

A series of advertisements for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

Packaging Notes

Molded polyethylene baby bib features a large catch-all pocket. Molded into bottom front, it traps falling food and keeps crumbs off floor. Bib washes along with dishes, is quick drying.

No-drip polyethylene pouring spout for milk bottles comes in sizes to fit quarts, halves, or gallons. Manufacturer claims it prevents spills and splashes, cleans quickly, lasts almost indefinitely. Available plain or imprinted with dairy name or logo.

New portable impulse sealer is useful for fabricating large items from polyethylene sheet, completely enclosing bulky items in polyethylene, or sealing polyethylene liners of large drums and bags. It consists of separate power pack and hand-operated sealing tongs; produces a seal 8" long, ⅛" wide. It can seal 2 pieces of up to 6 mils each.

Anti-static spray for polyethylene film works quickly and effectively on rolls, sheets, wherever static develops. Helps printers and converters of polyethylene packaging, bags, envelopes, etc. keep up high production rates—by chemically neutralizing static electricity generated by friction or atmospheric conditions. Comes in easy-to-use aerosol container.

Polyethylene packaging of brown and powdered sugar—recently introduced as "an industry first" by a California company—promises to minimize lumping and caking of these extremely moisture-sensitive products. Because polyethylene acts as a moisture barrier, it keeps the brown sugar moist, the powdered dry.

The 3-mil polyethylene bags used are 3-color flexographically printed. Size is 6½" x 13", suitable for inserting into a kitchen canister. And, once opened, the bag can be reclosed for continued freshness with a simple device offered by the company as a premium.

U.S.I. Doubles Polyethylene Capacity at Houston Plant

New Production Makes U.S.I. World's Second Largest Producer of Polyethylene Resins

A new section of U.S.I.'s polyethylene production plant at Houston, Texas, has just been started up. This new installation doubles the capacity of this plant, and establishes U.S.I. as the second largest producer of polyethylene in the world. This latest expansion brings U.S.I.'s total production capacity of PETROTHENE polyethylene resins to 300 million pounds per year.

View of U.S.I.'s polyethylene plant in Houston, Texas. With plant in Tuscola, Illinois, Company now has total production capacity of 300 million pounds per year.

Rapid Growth Since 1955

U.S.I. has grown rapidly in the polyethylene field. Its first plant with a 25 million pound annual capacity was started up at Tuscola, Illinois, in early 1955. This plant was doubled in size in 1956 and redoubled in 1957 to a capacity of 100 million pounds. In early 1959 the Houston plant was placed on-stream, with a 75 million pound per year capacity (soon increased to 100 million), and this new expansion doubles that plant capacity.

U.S.I.'s PETROTHENE resins have taken a strong lead since their introduction, especially in the film and paper coating markets. According to Vincent McCarthy, U.S.I. Director of Plastics Sales, this market position was built upon a policy of tailoring resin properties for specific applications. Within the past four months, for example, the company has developed and introduced a new produce-bag resin, a new paper coating resin, three new blow-molding resins, a new cast film resin, and two high-flow blending resins.

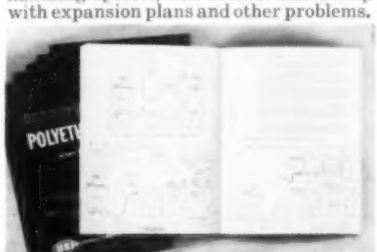
Production requirements for the new produce-bag resin are expected to make the largest single demand upon the new plant capacity. Introduced only this past April, demand for PETROTHENE 112 is already heavy, because of the unique combination of high-clarity and high-toughness it gives to produce bags and "general-purpose" film.

U.S.I. Announces New Booklet on Bulk Handling

"PETROTHENE® POLYETHYLENE . . . When to Use Bulk Handling," is a 24-page booklet prepared by U.S.I. to help resin users determine:

1. whether or not they should be buying in bulk.
2. which type of bulk packaging would best fit a particular plant's requirements.
3. which type of unloading system to choose.

Or, for processors whose plant is already equipped with a bulk materials-handling system, this booklet offers help with expansion plans and other problems.



Types of bulk conveyances used by U.S.I. to ship PETROTHENE resins are described. Graphs, tables, and calculation sheets show how net savings and payout time for capital invested in bulk handling equipment can be figured.

For copies, write to Technical Literature Dept., U.S. Industrial Chemicals Co., 99 Park Ave., New York 16, N.Y.

New Help for Blow Molders

U.S.I. has just released an 8-page Technical Data brochure entitled, "BLOW MOLDING . . . How to Obtain Highest Quality and Production Rate." It discusses mold cycle time and the more important properties of blow-molded items in detail; then, shows how each is affected by 8 variables.

This information is based on the results of an extensive research program currently being conducted by the U.S.I. Polymer Research Laboratories. Its aim is to find the resin properties and machine conditions which will result in the best product properties—at the most economical production rates. As the project continues, more reports will be issued.

For copies, write to Technical Literature Dept., U.S. Industrial Chemicals Co., 99 Park Ave., New York 16, N.Y.

MORE AND MORE... SHE REACHES FOR A POLYETHYLENE-COATED CONTAINER

with U.S.I.'s new PETROTHENE® coating resins

There's no doubt about consumer preference for dairy products, bakery goods, frozen food packaged in polyethylene-coated board containers. Now, improved coating resins developed by U.S.I. let you produce superior board for this market... at less cost and with fewer processing problems.

Grease resistance of the new resins is outstanding. For example, paper coated with PETROTHENE 205-15 (Melt Index-3, Density-0.924) passes Military Specification MIL-B-121-B for greaseproofness at lower coating weights than other resins of the same melt index and density. Adhesion, even with coatings as thin as 0.5 mil extruded at high rates, is excellent. Troublesome neck-in and curl problems are minimized... polymer build-up at the die, virtually eliminated.

PETROTHENE resin-coated board is tough, scuff-resistant... easy to print on and easy to seal over a wide temperature range. Packages made from it stay clean, smooth, sales-stimulating... with no leaking of contents... no grease wicking... no flaking off.

For complete information on these resins and technical assistance in using them, write to U.S.I.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N. Y.
Branches in principal cities

Photo credit—Naugatuck Chemical Co.

Plastics in Corrosion Control

Corrosion—one of the biggest headaches of the chemical industry—can be controlled, and in some instances, stopped, by the use of plastics. This feature describes some of the plastics available, and specific applications.

George H. Reed
American Hard Rubber Co.

Intelligent choice of plastics for equipment and materials application subject to corrosion is a vital problem of the chemical industry today. The interest is great, only on the part of basic materials manufacturers, extruders, molders, and other fabricators, as well as the chemical industry. Listed below are some of the materials now being used for pipe and fittings:

Type I—Acrylonitrile-Butadiene-Styrene (ABS)—This is a more heat-resistant and higher tensile strength, but lower impact resistant grade ABS. It is supplied mainly in thin wall types and utilizes socket weld type fittings. Standards will soon be issued.

Linear Polyethylene—This material has a higher temperature range than the medium and low density polyethylene which were the most widely used up to the present time. Standards are presently being prepared to cover this pipe material and should shortly be issued.

Polypropylene—Has good tensile strength, high heat resistance, and good impact resistance at ordinary temperatures. It is the newest of the polymerized wax type materials and while it looks to be an excellent corrosion resistant material for pipe and fittings, it has not reached standardization stages as yet.

Chlorinated Polyether—Has good tensile strength, high heat resistance, high impact resistance even at extremely low temperatures, and has excellent chemical resistance. It is expensive, and so far is being used only under extreme chemical corrosion

conditions. It has not reached standardization stages as yet.

Glass Reinforced Polyester—Pipe is being made from this material and has high tensile strength, fair chemical resistance. The pipe has not been tested for potable water as yet. There are no standards, as yet.

Fluoroethylenes—This group of thermoplastic materials provide lined pipe of very high temperature and corrosion resistance, but is not in wide general use for economic reasons.

Glass Reinforced Epoxy—Pipe is being made from this material and has high tensile strength, and excellent chemical resistance. The pipe has not been tested for potable water, as yet nor have any standards come into existence.

Some of the older thermoplastic and thermosetting materials still used widely for corrosion resistant pipe:

Cellulose Acetate Butyrate—This material has been withdrawn from N.S.F. approval for potable water because of the possibility of its imparting some taste and odor to the water. The material is still widely used in the petroleum industry for gas gathering, sour crude flow lines, and salt water disposal and in the gas industry.

Polyvinylidene Chloride—This rigid pipe and fitting material is widely used in chemical industry including chlorinating apparatus, electroplating, bleach, dyes, inks, oxidizing acids, etc. and is approved by the Food and Drug Administration.

Laminated Phenolic Pipe and Fittings—Pipe and fittings are made by one or two companies for specialized applications such as chlorine production. No standards exist.

Polyethylene—(Low and medium density)—This at present is the most widely used of any of the thermoplastic materials and has an operating temperature range of minus 65° to plus 125°F (low density material only). The greatest market for this product is in jet well installations rural water systems, cold water supply lines, sprinkler and irrigation systems. Pipe is packaged in coils up to 400′ in length in sizes ½ through 2″. Pipe 3″ and over is furnished in 25′ lengths.

Rigid PVC—Pipe and fittings are available in two types of material. Type 1, normal impact, has excellent chemical resistance and good impact strength. The operating temperature range is from minus 40° to plus 160°F. It is available in Schedule 40, Schedule 80 and Schedule 120 iron pipe sizes. It may be joined by either threaded or socket weld type fittings. Because of its excellent chemical resistance, it has found wide use in chemical and industrial plants for the transportation of corrosive liquids and also for the venting of corrosive fumes. Type 11, high impact, PVC has found wide use on the west coast for underground water lines and for the transmission of natural gas. It is also widely used for sprinkler systems in parks and watering highway landscaped areas. Type 11 PVC also is manufactured to Schedule A dimensions, which means that it has an iron pipe size (O.D.) but a wall thickness thinner than that found in Schedule 40 Pipe. The U. S. Navy has specified the use of Schedule 120 IPS rigid PVC pipe for washdown systems on its vessels to combat radioactive fall-out.

ABS (Acrylonitrile-Butadiene-Styrene) Type I—Pipe and fittings have an operating temperature range of minus 40° to plus 170°F. This pipe is furnished in sizes ranging from ½″ through 6″. It has a very high chemical resistance and excellent impact strength. Most industrial applications utilize pipe in either Schedule 40 or Schedule 80 iron pipe dimensions but it may also be obtained in 75 pound, 100 pound, 125 pound and 150 pound pressure rated pipe.

This pressure rated pipe has an SWP OD and is only joined by means of SWP size socket weld fittings. Standard pipe dies will not fit the OD of this pipe. The main uses of the pressure rated pipe are in water service lines from the main to the house, natural gas lines, corrosive salt water lines, and sour crude flow lines where paraffin is not a problem. It is also used as underground conduit.

Hard Rubber—For chemical applications, hard rubber is available as pipe and fittings; sheet, rod, and tube, from which chemical equipment can be fabricated; and special parts molded with limitless design possibilities. A special hand-fabricating process can be used for making tanks, large fittings, etc. Pumps are also available. Hard rubber is available for sustained high temperature applications in handling a wide variety of corrosive chemicals. Based on nitrile synthetic rubber (Buna-N), Tempron is a hard rubber with rigidity, heat resistance (to 275°F) and chemical resistance (at both room and elevated temperatures, it resists most chemicals). In addition, it has good resistance to many organic chemicals which attack soft rubber and plastics. At room temperature various grades resist aliphatic hydrocarbons such as hexane, hexene, and other solvents, such as ether, benzene, carbon tetrachloride, ethyl acetate, and benzaldehyde and oil. It is not recommended for strong oxidizing agents such as nitric acid. Hard rubber has high tensile strength of 8,500 psi., on a par or above with other plastics.

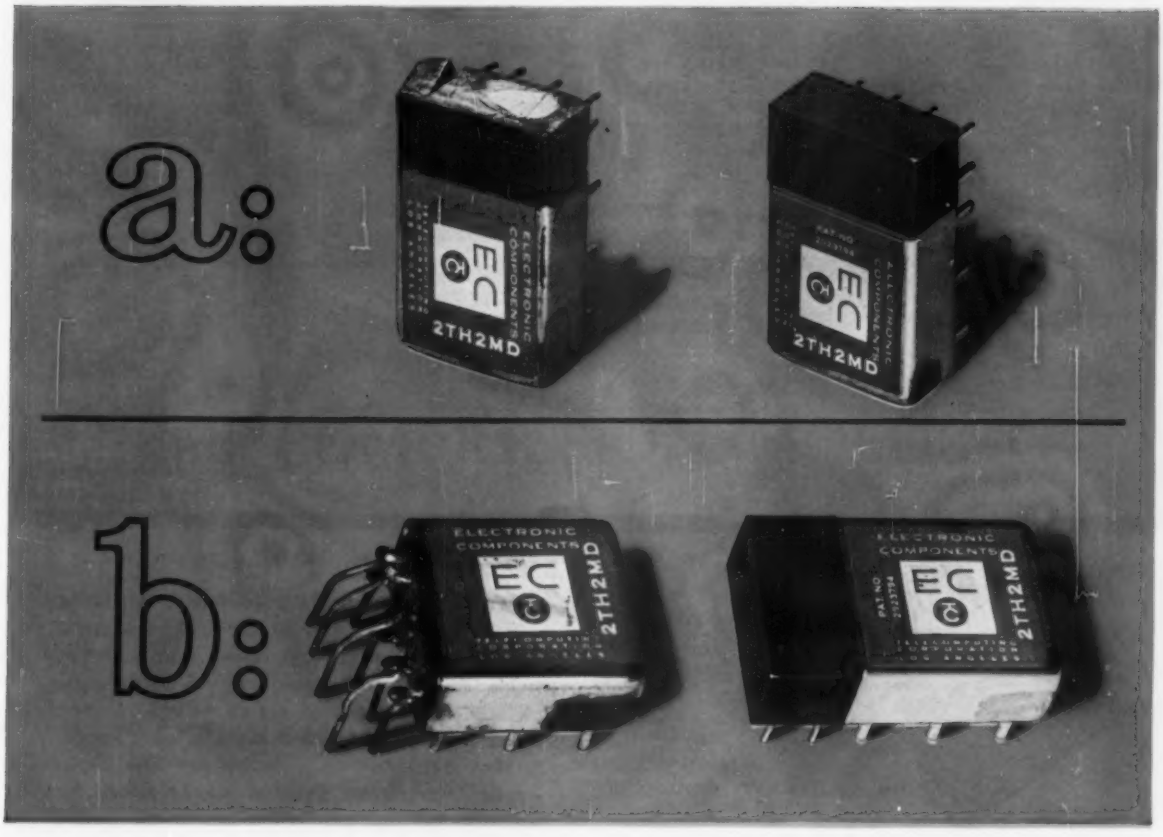
Linings—Pipe, fittings, valves, and tanks, can be lines or fabricated with many of the items of plastic or rubber heretofore mentioned.

—— ■ ——

One of the greatest deterrents to the widespread use of plastics is the lack of standards. Here are some steps being taken that will help remedy this situation.

- Committee D-20 on Plastics of ASTM has produced and will produce standards from raw materials
- SPI's Thermoplastic Pipe Division is working to overcome code and standardization problems, as well as developing technical data
- The plastic pipe manufacturers and raw material suppliers have begun a cooperative industry project on testing of plastic pipe to prove its suitability for use with potable water. This four year research program by the National Sanitation Foundation at the School of Public Health, University of Michigan, resulted in approval of certain types of pipe for use with drinking water, and the application of the NSF Seal of Approval to identify such pipe
- The ASTM and SPI jointly established Subcommittee XVII of Committee D-20 to develop ASTM specifications on plastic pipe and fittings. This group has developed specifications for solvent welded cellulose acetate butyrate pipe, method of test for short-time-rupture strength of thermoplastic pipe, and others
- American Standards Association (ASA) has organized Sectional Committee B-72 on Plastic Pipe

DOW | THERMOSETTING RESINS



TESTS PROVE DOW EPOXY NOVOLAC

outperforms conventional epoxies under extreme stress!

Potting relay terminal connectors for the guidance system of one of America's new missiles, a major electronic component manufacturer made a series of torture tests . . .

TEST a: To determine the effects of prolonged heat on two terminal relay potting formulations—one a high quality conventional epoxy resin, the other, Dow Epoxy Novolac (D.E.N. 438). Both were placed in a 180°C. oven. After five hours, the conventional epoxy resin potting cracked. But after 100 hours of continuous 180°C. heat, the potted terminal made from Dow Epoxy Novolac was unharmed!

TEST b: To compare the ability of each potting to withstand the action of high-powered degreasing solvents. The ordinary epoxy resin formulation was completely dissolved after only 48 hours in the stripper. But the potting made from D.E.N. 438 showed no significant change, even after two weeks' immersion in the same solvent!

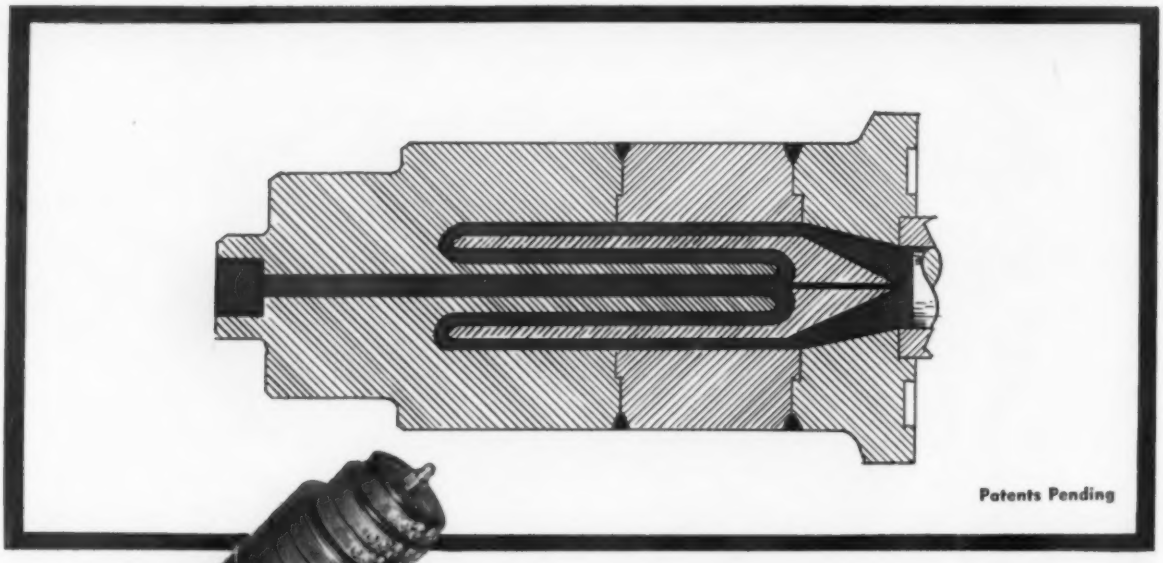
RESULTS: Proof once again that for potting, molding, encapsulating, laminating electronic components, or for any application where performance is critical, Dow Epoxy Novolac resins can provide the extra measure of physical and chemical stability necessary for success.

New applications for the Dow family of thermosetting polymers are being uncovered every day. If your application could benefit from their hardness, toughness, dimensional stability, and chemical resistance, call your nearest Dow sales office. Or write: THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Merchandising Department 1966EX10.

See "The Dow Hour of Great Mysteries" on TV.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

VRF Vented Reverse Flow Heaters



Patents Pending

Leading injection molders know— it's what happens INSIDE the heater that really counts!

Here's ultimate proof of IMS Leadership in heating cylinder design! The new exclusive VRF Degassing principle automatically overcomes many common molded-in defects. It's brought to you by the same cylinder engineers who pioneered the IMS Standard Uniform Design All-Welded Replacement Chamber in 1949. Note how the exclusive vent hole allows trapped, compressed gases to escape out of the melt area just prior to injection. This hot bleed-back speeds melting of cold granules, and often lowers pressure requirements by lubricating the spreader tip with soft plastic. You gain the advantages of precompression with no moving parts!

Cylinder corrosion on cellulosics is virtually eliminated by gas relief. Production time between clean-outs on Vinyl is greatly extended.

Pressure equalizing bleed-back gives automatic part weight control without a feed weigher.

VRF reduces burning because internal storage tube keeps material inventory away from heat source. Remember! It's what takes place INSIDE a heating cylinder that really counts!

IMS

SPECIAL PURPOSE REPLACEMENT
HEATING CYLINDERS FOR ALL
INJECTION MOLDING MACHINES.

INJECTION MOLDERS SUPPLY CO.

3514 LEE RD. CLEVELAND 20, OHIO

Ontario Section Regional Technical Conference Highlights Automation In Molding

Technology of two of today's fastest growing industries—plastics and automatic control—will provide the theme for an SPE Regional Technical Conference at the King Edward Sheraton Hotel in Toronto, Ontario, Canada, on November 7. Sponsored by the Society's Ontario Section, the one-day meeting on "Automation in Injection and Compression Molding" will accentuate the increasing and vital role played by automation in molding operations. The technical program includes nine papers in two concurrent sessions (injection and compression) covering process and automatic equipment developments, operating techniques and possible developments of the future.

Conference General Chairman J. MacKenzie Lees of Canadian Electric Co., Ltd., has announced that the luncheon speaker at the RETEC will be "Red" Storey, veteran National Hockey League referee. Society President George W. Martin will also address the luncheon group on the "Progress and Future of SPE".

The complete technical program as announced by Program Co-Chairman Lloyd Leadbeater of Toronto Plastics, Ltd., and Harold Hillsdon of Amalgamated Electric Corp. follows:

AUTOMATION in INJECTION and COMPRESSION MOLDING

November 7, 1960 • King Edward Sheraton Hotel • Toronto, Ontario, Canada

8:00 to 9:00 a.m.—Registration

Luncheon Program

George Martin, SPE President—Progress and Future of SPE.

Red Storey, National Hockey League referee, will be the guest speaker.

INJECTION MOLDING

SPARK EROSION MACHINING OF MOLD CAVITIES
Kenneth Birch
Electric Processes Co.

SELECTING EQUIPMENT FOR AUTOMATIC INJECTION MOLDING OPERATIONS
William G. Kriner
H.P.M. Div.
Koehring Co.

PUSH BUTTON MOLDING?
R. D. Balint
International Tools, Ltd.

SOME IMPORTANT CONSIDERATIONS IN AUTOMATIC MOLDING
John K. Neely
Dow Chemical of Canada, Ltd.

AUXILIARY EQUIPMENT FOR INJECTION MOLDING AND EXTRUSION OPERATION
Richard Denny
Whitlock Associates, Inc.

COMPRESSION MOLDING

AUTOMATIC COMPRESSION MOLDING
Roy Wilson
F. J. Stokes Machine Co. of Canada

LATEST DEVELOPMENTS IN PHENOLIC MOLDING TECHNIQUES
W. L. Caniff
Bakelite Co. Div. of
Union Carbide of Canada, Ltd.

TRANSFER MOLDING-PAST, PRESENT AND FUTURE
John L. Hull
Hull-Standard Corp.

SPARK EROSION MACHINING OF MOLD CAVITIES
Kenneth Birch
Electric Processes Co.

AUTOMATION IN COMPRESSION AND TRANSFER MOLDING
E. F. Borro, Sr.
Durez Plastics Div.
Hooker Chemical Corp.

Advance registration fee, which includes preprint book and luncheon, is $7.50 for SPE members and $9.00 for non-members. "On-site" registration fees are $8.50 and $10.00 respectively. Requests for further information and advance registration should be directed to:

John D. Glen, *Chairman, Registration Committee.*
Canadian Industries, Ltd.
1303 Yonge Street
Toronto, Ontario, Canada

Other major committee chairmen include: House, Donald Halbert, F. & H. Plastics, Ltd.; Printing, Alan Bowling, Durez Plastics Div., Hooker Chemical Corp.; Publicity, Harold A. Shure, Naugatuck Chemicals; Secretary, Miss Jane McNally, Canadian Plastics Magazine; and Treasurer, P. R. Boon, Monsanto Canada, Ltd.

COVINYLBLAK®...a dispersion of carbon black in vinyl resin—chip form.

COSTYRENEBLAK®...high quality colloidal dispersions of carbon black in polystyrene resin—concentrated granular form.

COLUMBIAN...

outstanding carbon black dispersions for plastics every step of the way!

COPEENBLAK®...a colloidal dispersion of carbon black in polyethylene resin—concentrated form.

AQUABLAKS®...water dispersions of carbon black for integral dyeing of synthetic fibers.

COWAXBLAK®...a colloidal dispersion of carbon black in chlorinated paraffin—chip form.

Whatever your need in the plastics industry ...Columbian's predispersed carbon blacks will meet your most exacting requirements efficiently and economically...provide unsurpassed quality...and profit!

COLUMBIAN CARBON COMPANY
380 Madison Avenue, New York 17, N. Y.

SPE'S NEWARK SECTION announces Regional Technical Conference

BLOW MOLDING COMES OF AGE

Friday, Nov. 18, 1960 • Hotel Essex House • Newark, N. J.

8:30-9:00 AM—REGISTRATION

MORNING SESSION

Moderator: W. H. Willert—Frank W. Egan & Co.

9:35— 9:50 AM	**History of Blow Molding** G. C. Heldrich—W. R. Grace & Co.
9:50—10:10 AM	**Applications & Markets** T. W. Mullen—Celanese Plastics Co.
10:10—10:30 AM	**An Introduction to Extrusion for Blow Molding** R. D. Sackett—Hartig Extruders
10:30—10:45 AM	INTERMISSION
10:45—11:05 AM	**Color for Blow Molding** A. B. Keown—Plastic Molders Supply Co., Inc.
11:05—11:25 AM	**Effects of Polyethylene Resin Type and Blow Molding Processing Conditions upon Item Quality** K. M. Webb, S. R. Melvin, D. A. Watson— Monsanto Chemical Co.
11:25—11:45 AM	GENERAL DISCUSSION

AFTERNOON SESSION

Moderator: A. Spaak—W. R. Grace & Co.

2:00—3:00 PM	Machinery Panel Moderator: G. Tanner—Auto-Blow Corp. **Injection Parison Blow Molding** E. P. Moslo—Moslo Machinery Co. **Alternate Feed Dual Crosshead Type Blow Molding Machinery** L. J. Kovach—Modern Plastic Machinery Corp. **Accumulator Feed, Single Crosshead Type Blow Molding** G. H. Pickering—Air-Formed Products Corp. **Blow Molding of Hollow Articles on Indexing Rotary Equipment** D. Rainville—The Rainville Co., Inc. **Rising or Side Moving Mold, Single Head Type Blow Molding Machine** I. Thomas—Newark Plastic Machinery Corp.
3:00—3:20 PM	**Blow Molding Processes and Techniques** R. L. Wechsler—Union Carbide Plastics Co.
3:20—3:30 PM	INTERMISSION
3:30—3:50 PM	**Molds for Blow Molding** J. F. Redman, Jr.—Redman Pattern Works
3:50—4:10 PM	**Patent Problems Facing U.S. Blow Molders** W. A. Schaich—Owens-Illinois
4:10—4:30 PM	GENERAL DISCUSSION

LUNCHEON—12:00 TO 2:00 PM

Address by G. W. Martin, President, Society of Plastics Engineers
Address by L. P. Carlin, Mayor, Newark, N. J.

Luncheon Speaker: Thomas H. Risk, Manager
Ford Motor Company
Engineering Research

NEWARK OFFERS THE BEST OF TRAVEL FACILITIES BY AIR, TRAIN OR BUS

Please make your travel & hotel reservations as early as possible. An advance registration form is reprinted below for your use.

Newark is but: 30 Minutes from Times Square, 1 Hour from Boston, 1½ Hours from Washington, 3 Hours from Chicago.

CUT ALONG THIS LINE

Advance Registration Card

NEWARK REGIONAL TECHNICAL CONFERENCE—SOCIETY OF PLASTICS ENGINEERS, Inc.

"BLOW MOLDING COMES OF AGE"

FRIDAY, NOVEMBER 18, 1960—HOTEL ESSEX HOUSE, NEWARK, N. J.

Name _____ *Address* _____

Company _____ *Title* _____

MAKE CHECKS FOR REGISTRATION PAYABLE TO: "NEWARK SECTION-SPE"

MAIL CHECKS AND THIS CARD TO: Mr. David A. Jones
Celanese Plastics Co.
744 Broad Street Newark, N. J.

Registration Fee:

SPE and SPI Members	**Non-Members**
Advance $10.00	Advance $13.00
At Conference $11.00	At Conference $14.00

(Fee includes Luncheon Ticket and RETEC Preprint Book)

Please check one for Luncheon: Meat———Fish———

Hotel accommodations may be arranged directly with Hotel Essex House, Newark, N. J.

Please Check

SPE Member ☐
SPI Member ☐
Non-Member ☐

Committee Only

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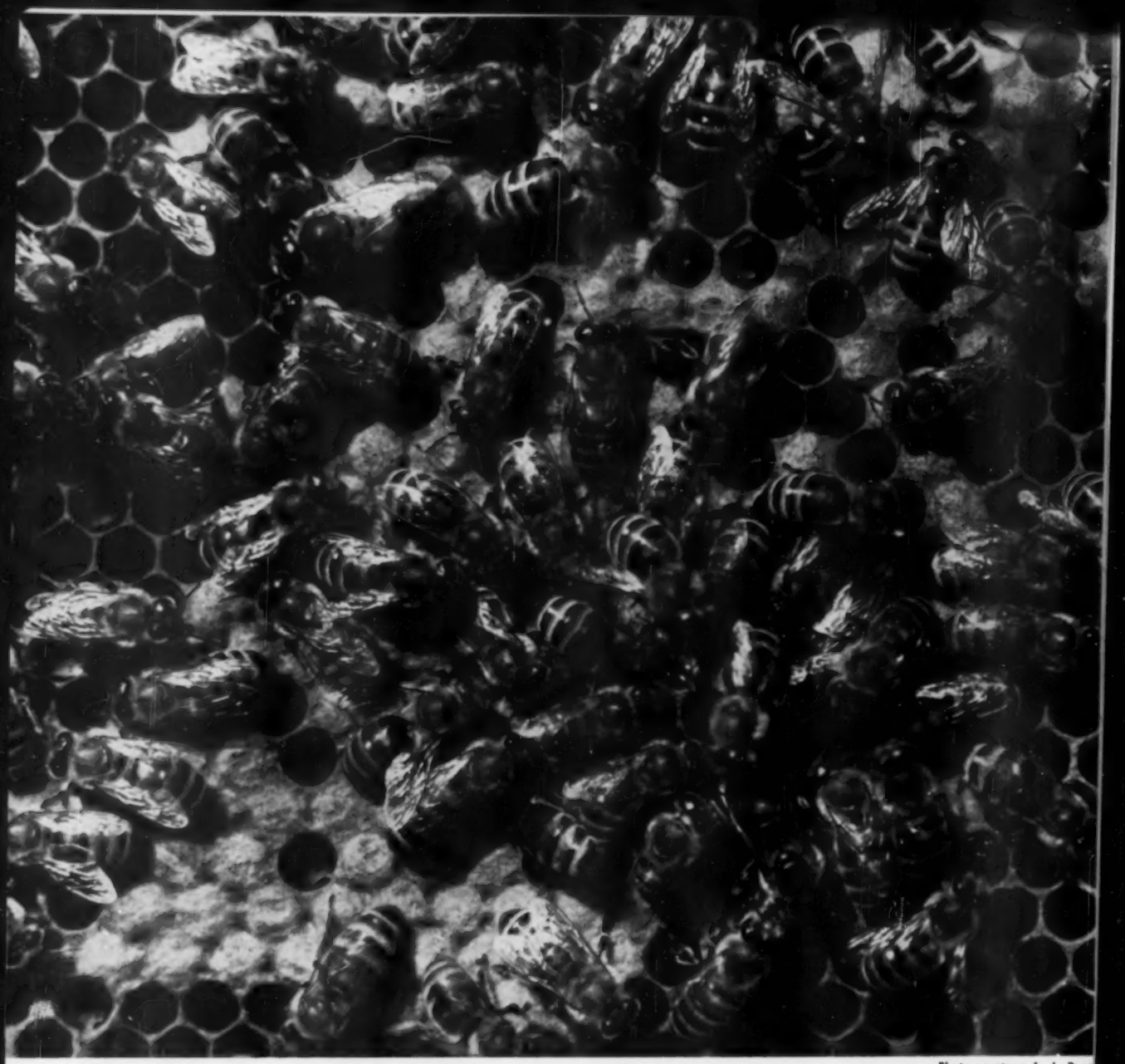

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SPEAKING OF EXTRUSION

Effects of Controlled Wattage on Extruder Barrel Temperatures

This article describes a unique system of controlling heater wattage on extruder barrels. The system results in controlling temperature variation to an average of 1°F. It is available as an extra in purchasing new equipment and can sometimes be applied to machines already in the field.

Since the time electrically heated extruder barrels were first introduced some fifteen years ago, it has been generally recognized that cylinders heated in this manner are not maintained at constant temperatures. This effect is apparent whether "on-off" control instruments or the widely employed, so-called "proportioning type" instruments are used. At best, the temperature variations at the barrel liner of a standard extruder will run on a cycle having a 5°F amplitude about the set point, and in some cases will run to 10°F or higher. The following paragraphs will summarize a study and analysis of this problem recently completed in this laboratory.

The apparatus used for this study is illustrated schematically in *Figure 1*. For purposes of these tests, the center temperature control zone (ordinarily the most critical) on the three zone barrel of a 2" bore laboratory extruder was isolated, and provided with special instrumentation. Since we were mainly interested in control of the cylinder itself, all tests were run in the steady state condition, i. e. with no material being processed in the machine. A common type of temperature recording instrument was used to sense the barrel liner temperature at all times, and this instrument was accurately calibrated. Various types and brands of control instruments were used, and these will be identified in this article as instrument A, B, C, or D. The temperature sensing elements used with these instruments also were

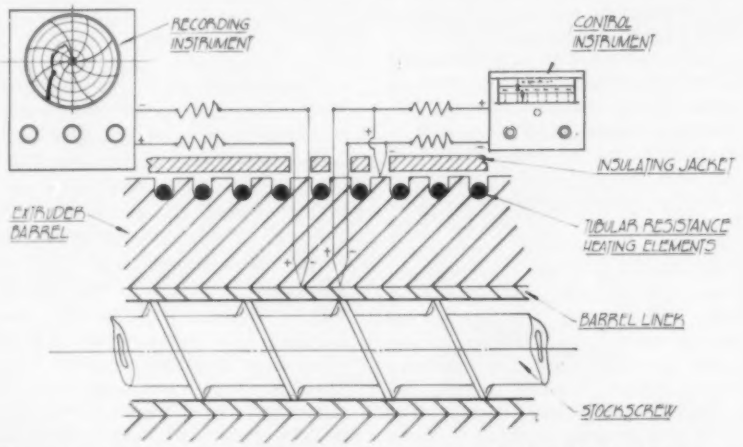

Figure 1. Equipment used in studying effects of controlled wattage on extruder barrel temperatures. All tests were run with no material being processed in the machine

of varying types and applied at different locations, as described in each individual case. Because heater wattage was recognized to have a major affect on temperature control, the tubular resistance type heating elements used to heat the barrel were provided with an electrical switching system. By connecting the eight heaters of the zone (four pairs) in series, half voltage, and therefore quarter wattage, was obtained on each. A system known as *Dual Voltage*, which has been used in production machines was also available, providing automatic switching between full and half voltage based on a built-in time delay relay. Half wattage in the zone could also be obtained by dropping half of the eight heaters out of the circuit.

Initial tests were performed with what is generally accepted as a standard arrangement of barrel temperature control elements. A single control temperature sensing point was located as closely as possible to the cylinder bore, and the control instruments were of the common anticipating type. The instruments energized a power contactor which, in turn, supplied full voltage to the heaters when called for. Instrument "A" used a standard iron-constantan thermocouple, while instrument "B" operated with a thermistor type temperature sensing probe. At a set point of 445°F, the charts for both these instruments were so nearly alike that only one (that of instrument "A") has been reproduced in *Figure 2*. This indicates a surprising temperature variation of greater than 10°F. It might be added, that similar instruments of all manufacturers mentioned in connection with this article were run through this test without any marked change in the results.

The test chart reproduced in *Figure 3* utilized the same set-up as above, except that the previously described *Dual Voltage* system was used to control the heaters. The indicated variation is approximately 8°F with a set point slightly under 450°F. This cycling was thought to be a result of an inability to maintain 450° with only half voltage on the heaters, so that the system automatically kept switching between full and half voltage. The very small 2° variation in the second half of the chart was obtained by removing the time delay relay which kept half voltage on the heaters continually. This proved our above assumption to be correct, since the temperature leveled out at approximately 10° below the set point. The chart is a graphic illustration of the importance of matching wattage to barrel size for accurate temperature control.

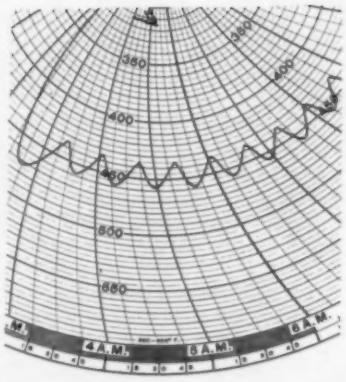

Figure 2. Temperature control chart from standard arrangement of barrel temperature control elements. Note surprising temperature variation of greater than 10°F

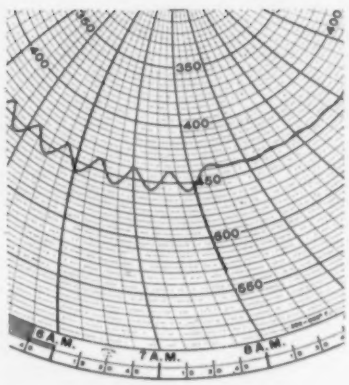

Figure 3. Test chart shows results with standard temperature control elements, except that the Dual Voltage system was used to control the heaters. Variation is only about 8°F with a set point slightly under 450°F

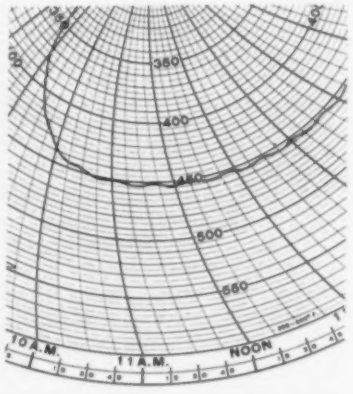

Figure 4. Test chart shows fairly even temperature control over an extended period of time. Dual thermocouple arrangement was used, as shown in Figure 1

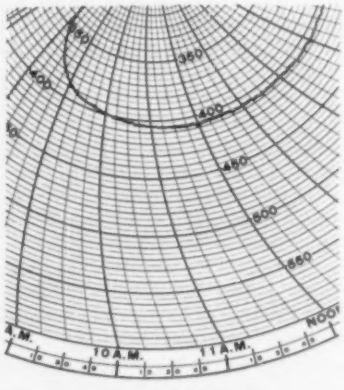

Figure 5. Test chart shows temperature variation held to an average of 1°F. Set point was 405°F. System was controlled by controller having dual thermistors positioned the same as the dual thermocouples used in the system described in Figure 4

Figure 4 depicts a chart showing fairly even temperature control over an extended period of time. This result was obtained through the use of another common anticipating type controller we shall call Instrument "C". However, in this case a dual thermocouple arrangement was used as illustrated in *Figure 1*; two thermocouples connected in paralled, one located at the heater surface and the other deep in the barrel metal. Once again ¼ wattage was applied, as in the second part of *Figure 3*, but, since it had been determined that this wattage would not maintain the preset temperature, additional insulation was added. At a set point of approximately 455°, this gave a variation of 1½°—slightly better than the single thermocouple used in *Figure 3*.

The best control obtained in any of the tests is illustrated in *Figure 5*, which shows temperature variation held to an average of 1°F at a set point of 405°F. In this case, the system was controlled by instrument "D", an on-off controller employing dual thermistors positioned the same as the dual thermocouples used in the previous case. Half voltage (¼ wattage) was applied to the zone heaters. Several anticipating type instruments were tested in this identical set-up, with none showing any marked improvement in control, and some actually increased the variation.

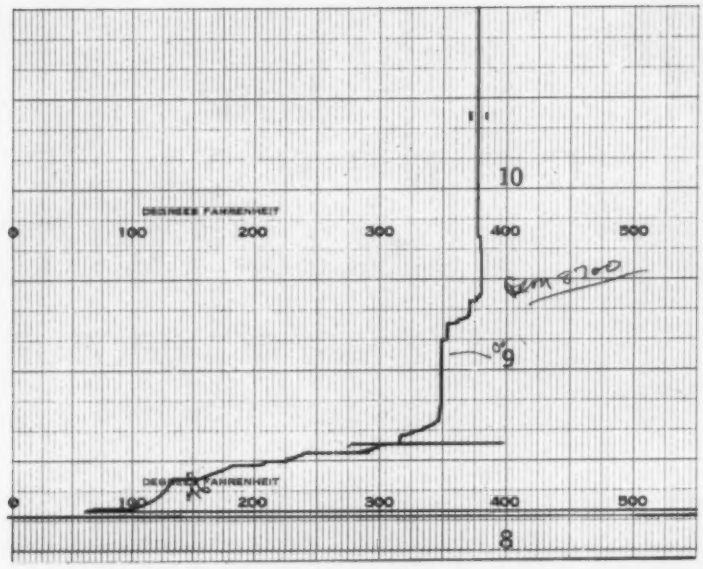

Figure 6. Temperature record chart of extruder having a switching system installed to control heater wattage. Record was made on production run while extruding PVC pipe

Many tests were run utilizing various types of temperature control instruments built by different manufacturers, who are listed at the close of this article. Unfortunately, space does not permit going into more of these examples in detail. However, the cases cited were felt to be representative of our overall findings, which pointed out two main avenues of approach toward improving extruder barrel temperature control. These were the dual thermocouple or thermistor system for the control temperature signal and some means of controlling wattage in a given temperature control zone.

Instrument Manufacturers Cooperating in Tests Described in This Article

Brown Instrument Div. Minneapolis-Honeywell Reg. Co.
Electronic Process Corp. of California
Fenwal, Inc.
Thermo-Electric Co., Inc.
West Instrument Corp.
Wheelco Instrument Div. Barber-Colman Co.

On the whole, for all wattage conditions, dual thermocouples and thermistors gave better control than single elements of either type. Nevertheless, even this arrangement will not control accurately where heater wattage is not properly matched to the barrel size. For this reason we felt that the single most important factor in reducing temperature fluctuations is to regulate in some way the heater wattage being applied to the controlled zone. An instrument designed for this purpose is the saturable core reactor type, which has developed mainly for use on extrusion dies. Unfortunately, the cost of these instruments becomes prohibitive on large size extruders, where heater wattage in a single zone may total as high as 20 or 25 KW.

Therefore, a switching system as previously described and used on the lab unit, would seem economical and desirable for the purpose of controlling heater wattage. The system is available as an extra when purchasing a new extruder, and can sometimes be applied to machines already in the field. This has been done to several units, and a temperature record chart of one such extruder has been reproduced in *Figure 6*. It was made on a regular production run while extruding PVC pipe with dual thermistor control as in *Figure 5*.

—■—

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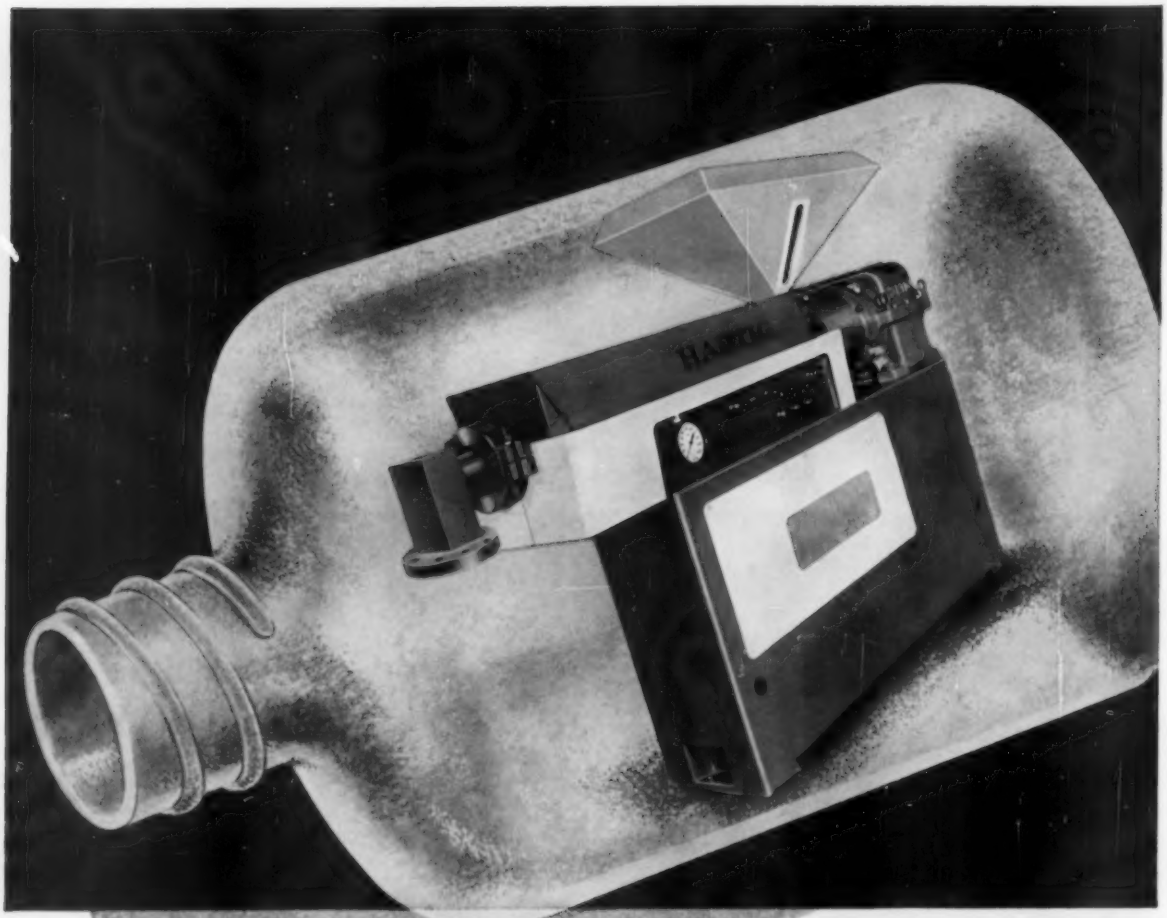

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Mobay Chemical Company

MOLDING CYCLES

This article describes a process for molding thin sections of one-shot polyether foams in thin gage metal molds. Unique feature of the process is a high-output source of radiant heat

Molding Flexible Polyether Urethane Foams

The processing of free-rise flexible urethane foam slab stock has been well established commercially since its introduction in this country five years ago (1). The preparation of closed-molded flexible foam, although receiving much attention during this same period (2), has not advanced to such proportions. This has been due primarily to problems including difficulty of reproducibility, mold release, a need for better foam properties, and foam densification during molding.

An additional reason of lesser importance but, nevertheless, contributing to the slow commercial development of molding, has been the major changes in foam technology occurring during this same period. Nearly complete change over from polyester based foams to polyether prepolymer foams to polyether one-shot foams has transpired. It is understood, however, that the advent of the more generally accepted polyether foams with their superior properties and economics has been the chief factor stirring the interests of foam raw material suppliers and foam manufacturers in molding.

Formulation

The formulation used for the moldings described in this article consisted of the following polyol mixture which is given in parts by weight:

Niax Triol* LG-56 (polyoxypropylene triol, glycerine based, MW 3000)	100
Niax Diol 2025 (polyoxypropylene dial, MW 2000)	33
Trichloromonofluoromethane	10
Stannous octoate	0.73

The mixture was prepared by combining the polyethers, then adding the trichloromonofluoromethane and finally stirring in the stannous octoate. Blending was best effected at room temperature. When stored under normal conditions, it was not necessary to cool or pressurize the polyol mixture in order to keep the trichloromonofluoromethane in solution.

The stability of the mixture was good. There were indications, however, that the activity of the stannous octoate was somewhat decreased on prolonged storage (greater than sixteen hours).

This polyol mixture was foamed according to the recipe given below.

Polyol Mixture	100 parts by weight
Mondur** TD-80 (80:20 mixture of 2, 4-and 2, 6-isomer of tolylene diisocyanate	36.7

formulation continued on page 1118

** Mobay Chemical Company
* Union Carbide Chemical Company

Table 1. Summary of Machine Conditions for the Molding of Flexible Polyether Foams

Machine, type	Mobay Continuous Machine (MF)	Mobay Intermittent Machine (M-13)
Resin rate, grams/min.	7900	7150
Resin temperature, °C.	26-30 (rm. temp.)	26-30 (rm. temp.)
Agitator speed, rpm.	5200	5100
Mixer size, diam. mm × length, mm.	50 × 100	50 × 70†
Mixer capacity, cc.	250	25
Nozzle extension, length, in.	8	1¼
Nozzle orifice, diam., mm.	12-13	25-26

† Dimensions at top of tapered mixer.

Dabco (Houdry) -triethylenediamine Silicone Copolymer L-520 (Union Carbide Chemicals Co.)	0.25
	2.0
Water	3.0

The ingredients of the recipe were metered to the mixer of the foam machine as four components: (1) The polyol mixture was delivered by a gear pump; (2) the TD-80, (3) a mixture of the triethylenediamine and water, and (4) L-520 were delivered by separate Bosch injection fuel pumps.

Mixing

All foaming was done on Mobay continuous feeding or intermittent feeding foam machines (3). A summary of the conditions used for each operation is given in *Table 1*.

Molding Cycle

The molding cycle was short and simple. The mold was coated with release agent, preheated to 35° -40°C, and filled by making a single pass under the stationary head of the foam machine. The conveyor speed allowed for a charge time of 10 seconds with the foam machine delivering 24 pounds of prefoam mixture per minute. The mold was then closed and immediately conveyed into a high capacity radiantly heated oven. At the end of three to five minutes, during which time the temperature at the mold-foam interface was raised from 35 to 100°C., the mold was conveyed out of the oven. The molded foam was immediately removed from the mold if a wax release agent was used. When a flexible polymeric type of release agent was used which became an integral part of the foam, release occurred 6-7 minutes after the mold was taken out of the oven. Thus the entire mold cycle required a total time of 5 minutes in the first case and 10-11 minutes in the latter.

Immediately following the removal of the molded foam from the mold, it was crushed a single time to 50% deflection. The molded foam was then given a post-treatment in atmospheric steam for 30 minutes followed by a dry cure at 130°C for one hour.

The oven was heated by 60,000 watts of chrome ribbon over an area of 16 sq. ft., divided evenly above and below the mold and about 5 inches from the mold surface—all of this being enclosed in a masonite constructed chamber.

Effect of Foaming Temperature

The process of foaming involves two highly exothermic chemical reactions, viz., the reaction of polyisocyanate with polyether and with water. The effect of the exothermic nature of these foaming reactions on the temperature during foaming of a one-shot polyether foam is shown in *Figure 1*. It is seen that the temperature during one-shot slab stock foaming undergoes a very sharp increase from ambient to 100°C in 2 min. (about the time of completion of foam rise).

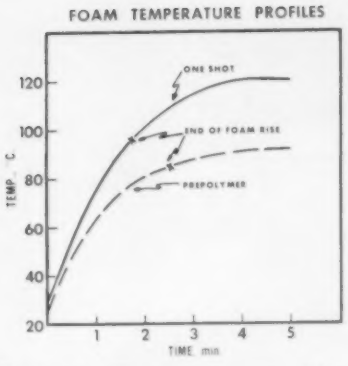

Figure 1. Temperature profiles for free rise one-shot and prepolymer polyether foam

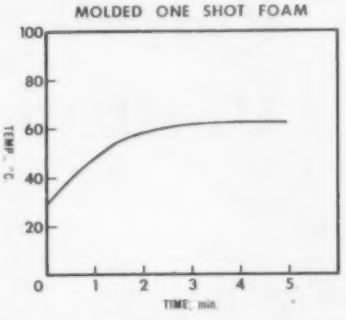

Figure 2. Temperature profile for one-shot molded polyether foam

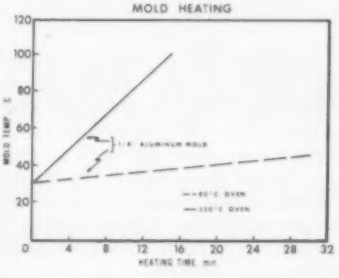

Figure 3. Effect of convection heating on mold temperature

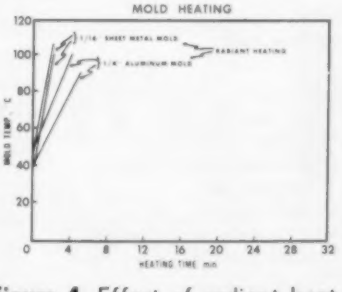

Figure 4. Effect of radiant heating on mold temperature

The foaming technique used, that is, whether one-shot or prepolymer, governs to a great degree the rate and extent of the rise in foaming temperature. The so-called "one-shot" technique which pertains to the simultaneous mixing and reaction of polyisocyanate, polyether and water, provides the highest possible exotherm (150°C max.). Thus, the self-curing characteristics of foams prepared by this manner are readily explained providing other conditions of foam thickness and foaming environment are right. The "prepolymer technique" which allows the preparation of foam by effecting the reactions between polyisocyanate, polyether and water in two distinct and separately controlled steps gives considerably lower foaming temperatures as shown in *Figure 1*. In this case, the temperature rise when foaming is slower and the maximum exotherm is much lower than with the one-shot technique.

The temperatures reached when foaming by the prepolymer technique even in thick sections are not sufficiently high to induce self-curing so that post-curing at high temperatures is usually necessary in order to get the best physical properties, particularly, compression set (5).

Another factor related to foam thickness influencing the temperature of foaming is the environment in which the foaming occurs. *Figure 2* shows the rise in exotherm of a one-shot foam when it is completely surrounded by metal. The low exotherm is the result of heat loss to the metal surroundings. Conclusion: Best results can be obtained by preventing the heat loss to the metal mold. *Figure 3* indicates how critical the method is. *Figure 4* shows how effective radiant heat is for raising the temperature of the mold foam interface so that the rate of exotherm approached that of a free-rise block.

Mold Construction and Operation

To make maximum use of the heat supplied by the high heat capacity oven, thin gage (16) steel molds were used for this molding development. Better heat transfer could have been

Typical Physical Properties of Molded Foam Topper Pads (4)

Density, pcf.	2.0
Tensile strength, psi	17.0
Aged*	15.0
Elongation, %	320
Aged*	310
Tear strength, lbs./in.	2.7
Compression Set, %	
90%, 6 hrs.	9.0
Aged*	9.8
50%, 22 hrs. (based on orig. thick.)	8.0
Aged*	8.5
Indent, lbs./50 sq. in. (measured on pad thickness of 2")	
25%/25% R	19.5/17.5
50%/50% R	35.5/30
65%/65% R	54/48.5
75%/75% R	95/81
Compression deflection, psi at	
25%/25% R	0.23/0.19
Aged*	0.19/0.16
50%	0.29
Aged*	0.24
75%	0.69
Aged*	0.60
Shear Resistance	Good
Dry Oven Aging**	Good

* Aging Condition: Autoclave, 5 hrs. at 250°F and 12-15 psi.
** Aging Condition: Dry oven at 140°C for at least 24 hrs.

obtained from aluminum but in this case the steel performed satisfactorily.

The mold temperature at time of charging was found critical. Best results were obtained when the mold surface was heated or cooled to 35-40°C prior to filling. Introducing the prefoam mixture at temperatures below 35-40°C resulted in poor release and loose skin formation; charging the mold at temperatures above 33-40°C caused irregular cell structure directly beneath the skin and a greater tendency for the pad to stick to the mold surface.

Mold Closure

Two techniques were used for controlling the thickness of the topper pads molded. Both involved the use of a floating lid which was free to rise when the foam came in contact with it. By one technique, the lid was heavy enough to force the foam back to a controlled lower level after completion of the foam rise. In the second technique, the lid was pushed back to a controlled lower level by externally applied pressure and then clamped into place. The latter technique provided the better control of molded foam thickness. On the other hand, the former also afforded good control of foam thickness when accurate charging and even distribution of prefoam mixture were achieved.

The clamping of the lid in place at the time of closing the mold resulted in splitting and voiding.

Mold Release

Mold release has been greatly improved through the technique of applying heat to the mold during the foaming process.

Two release systems were used in connection with this work and are described below:

Wax Release

Commercial waxes such as Shanco Wax (32-6), Shanco Plastics and Chemicals, Inc., and Perma Mold (3-27 or 3-26D), Brulin and Co. were brushed on the surface of the mold at a temperature of 250°F. On subsequent cooling of the mold to 35-40°C. the molding process was followed according to the description given. The molded topper pad was removed from the mold in five minutes when the mold temperature was above the melting point of the wax (above 160°F). Release from the molten wax was quick and easy and a thin, soft continuous skin was formed having a low degree of porosity. The wax had to be applied for each molding cycle.

Silicone Rubber-Latex Release

This release involved a combination of permanent (silicone rubber) and non-permanent (latex) types of release agent. It provided a flexible polymeric non-porous skin which became an integral part of the molded foam during the molding process. The silicone rubber, Silastic 501 (Dow Corning) or RTV-60 (General Electric), was cured on the metal surface of the mold according to the supplier's directions. Prior to molding, Neoprene Latex Emulsion 735 (duPont) was applied to the silicone rubber substrate by spraying. The preheating of the mold to 35-40°C. was sufficient heat for driving off the water of the emulsion. The reported molding cycle was followed but leaving the mold in the high capacity oven only long enough for the foaming temperature to reach 100°C. (2-3 minutes). The mold was taken out of the oven and release of the topper pad was effected in 6-7 additional minutes, after considerable cooling down of the mold had taken place.

Foam Densification

Foam densification has practically been eliminated using the application of radiant heat during the foam rise of the molding cycle. Over-all pad densities (including all flash and skins) of 2.0 pounds per cubic foot have been obtained from a recipe normally giving a density of 1.8 pound per cubic foot in a free rise untrimmed blocks. This is about a 11% increase in density. Similar moldings conducted under ambient conditions usually result in density increases of 50% or greater.

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REINFORCED PLASTICS

Methyl Acrylate As A Monomer in Glass Fiber Reinforced Polyester Laminates

Methyl methacrylate modified resins show weather resistance and light stability superior to standard polyester resins using only styrene as a cross linking monomer

Over the past ten years one of the larger consumers of polyester resins has been the translucent panel industry. Various estimates indicate a production of about 70,000,000 square feet in 1959 with most of this material being used for outdoor applications. Two of the main problems which have been encountered by the users of translucent panels have been the inherent poor light stability and the poor resistance to weathering on exposure to sunlight and moisture. Considerable effort has been put forth to improve these properties by both the resin suppliers and panel manufacturers. The development of improved purity of raw materials and the use of ultraviolet absorbers have improved the light stability of the resins. Improvements in weather resistance as evidenced by retention of gloss and original surface condition have been obtained by use of special production techniques to obtain a crinkle or pebble finish, by the use of surface mats, or by the use of monomers other than styrene, such as methyl methacrylate. A crinkled or pebbled surface essentially gives a panel which is resin rich in the areas of the crinkles or pebbles; and therefore, a higher average weather resistance. A surface mat or veil applied over the chopped strand mat tends also to give a resin-rich surface by floating a resin layer over the glass filaments. Various monomers have also been used and methyl methacrylate modified resins show weather resistance and light stability superior to standard polyester resins using only styrene as a cross linking monomer.

The use of monomers other than styrene with polyester resins for translucent panel application has been investigated previously, but except for methyl methacrylate (MMA) other monomers are not used in any appreciable amount.

Investigation of the use of other monomers led to this evaluation of methyl acrylate. Methyl acrylate (MA) was found to be completely compatible with polyesters and more than satisfied the basic requirements of improved light stability and weathering resistance without adversely affecting the other properties of the reinforced laminates. In fact, the methyl acrylate modified laminates were found to have increased physical properties over non-modified laminates. Except as may be cited in specific instances, all tests were conducted using Polylite 8100A polyester resins, rubber grade styrene, and MA inhibited with methyl ether hydroquinone.

Weathering Tests

The evaluation of weathering properties is desirably based on long-term outdoor exposure. Because of the improvement found in MA modified laminates, no change in surface condition was noticeable after one year's outdoor exposure, and the evaluation covered is based on laboratory accelerated testing.

Laminates with 2-ounce chopped strand glass fiber mat were produced with varying amounts of MA-styrene-resin and subjected to ultraviolet exposure tests. Tests were conducted using three, 275 watt, RS sunlamp bulbs mounted in a triangle 10 inch on center over a table rotating at 33-1/3 RPM. Specimens were placed directly on the table 4½ inches below the bottom of the lamps. Visual examination after 48, 96, and 144 hours exposure showed increasing light stability with increasing MA percent-

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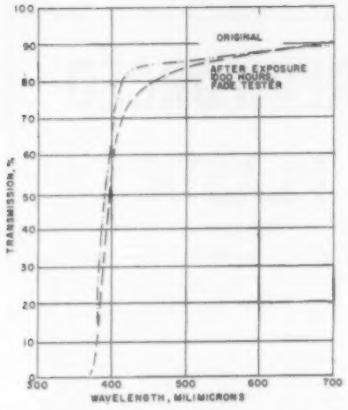


Figure 1. Spectral Transmission of Polyester—20% Styrene

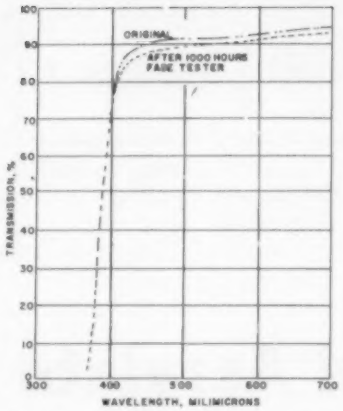


Figure 2. Spectral Transmission of Polyester—5% Styrene, 15% Methyl Acrylate

ages. This was true whether the MA was substituted for an equal percentage of styrene by weight or used merely as an additive to a predetermined styrene-polyester mix.

Further work was conducted where a series of specimen castings were exposed on a Fadeometer. These castings were made using a mix consisting of 80 percent polyester resin and various combinations of styrene and MA to give a 20 percent monomer addition. The resin was cast between cellophane-covered glass plates and was cured with ⅜ percent B.P.O. and ⅜ percent C.H.P. in a circulating air oven at 180°F. The light transmission in the visible range was measured on a recording spectrometer before exposure on the Fadeometer and after 500 and 1,000 hours exposure. The transmission curves for two of these tests are shown in *Figures 1 and 2*. Transmission curves for other combinations of MA and styrene and also for 500 hours exposure were very similar and those shown are considered typical. It was noted that although the light transmission is reduced in all tests after 1,000 hours exposure, with increasing percentages of MA the curves tended to be parallel while the all-styrene curves cross in the range of 600 mu. This is in the yellow-orange region of the spectrum and may account for visual yellowing of the styrene polyester laminates. The parallelness of the transmission curves of MA laminates before and after ultraviolet exposure tend to show quantitatively that there is little visual yellowing of the laminates as there is no disproportionate displacement of the curves.

Laminates were prepared using 2 ounce chopped strand glass fiber mat, various MA-styrene-resin mixes and in both smooth and crinkle finishes. Laminates were exposed in a Weather-ometer in accordance with ASTM Method of Test E-42-57 (Rec. Practice for Characteristics of Standard Carbon Arc Accelerated Weathering Unit). The test cycle consisted of 102 minutes of arc light followed by 18 minutes of light and water. The visual examination of the specimens showed again that MA laminates discolor only very slightly as compared to a styrene laminate. *Figure 3* shows two laminates after 2500 hours in the Weather-ometer. These two laminates were both of the same initial white color and were tested under the same conditions in the Weather-ometer. Not only is superior light stability noticed, but there is no evidence of fiber show or loss of surface on the MA polyester laminate. *Figure 4* shows a comparative set of specimens after 1800 hours in the Weather-ometer. These specimens were all of the same initial white color, crinkle surface both sides. Both the MA and MMA modified resin laminates are much superior to the standard styrene resin laminate. The MA is also slightly better in light stability than the MMA modified laminate, but in neither case is there any evidence of surface fiber pattern which is visible on the standard laminate.

Physical Properties

As stated previously, improvement in physical properties was not a basic premise of this evaluation. These basic physical tests were conducted to insure that the use of MA had no detrimental effect on physical properties.

Standard commercial translucent glass fiber reinforced panels are sold in a nominal 1/16 inch thickness using chopped strand glass mat with a nominal weight of two ounces per square foot before corrugating or forming. However, because of the difficulty in testing 1/16 inch thick laminates, ⅛ inch thick laminates were prepared using two layers of two ounce mat. Various combinations of MA-styrene-resin were used. Laminates were cured with ½ percent B.P.O. and ½ percent C.H.P. between cellophane covered metal molds in an hydraulic press at 190°F. and 30 psi.

Flexural Strength. Specimens were cut from these laminates and tested in accordance with ASTM D790-58T (Method of Test for Flexural Properties of Plastics). Because of the random pattern of the glass reinforcement, tests were conducted without regard to location of the specimens within the laminates. Results of these tests are given in *Table 1*. To verify that the increase in flexural strength originally noted with the Polylite 8100A resin was not related to the use of a

Table 1. Flexural Strength of Polyester Laminates Using Methylacrylate Monomer

Resin*	Resin %	Styrene %	MA %	Thickness Inches	Flexural Strength, psi	Flexural Modulus 10^6 psi
A	80	20	0	0.125	23,040	—
A	80	15	5	0.110	24,640	—
A	80	10	10	0.115	30,260	—
A	80	5	15	0.106	30,300	—
A	80	0	20	0.122	28,680	—
B	80	20	0	0.111	20,100	0.98
B	80	10	10	0.117	27,260	1.25
A	80	10	10	0.134	26,320	1.13

All laminates contained nominal four ounce glass fiber mat, 28% glass by weight.
* A Polylite 8100A, Reichhold Chemicals Company.
B Selectron 5155, Pittsburgh Plate Glass Company.

specific resin, a second set of specimens was produced with Selectron 5155 resin. Two sets of data are given in this table and although the second set has flexural strength values slightly lower than that of the first set of data, the percentage increases for corresponding laminates is approximately the same. All tests indicate an approximate 30 percent strength increase as a result of replacement of 10 percent MA for 10 percent styrene.

Table 2. Impact Strength of Polyester Laminates Using Methylacrylate Monomer

Resin	Resin, %	Styrene, %	MA, %	Izod Impact Strength Ft. Lb./In. of Notch
A	80	20	0	9.25
A	80	15	5	9.72
A	80	10	10	9.29
A	80	5	15	9.27
A	80	0	20	8.99

Impact Strength. Specimens prepared from the laminates previously described were tested for Izod notched impact strength in accordance with ASTM Test D-256-56 (Method of Test for Impact Resistance of Plastics and Electrical Insulating Materials). The results of these tests are given in *Table 2* and do not indicate an apparent increase in impact strength with increased percentages of MA. Quite probably this is due to the glass fiber mat rather than the resin system being the controlling material.

Properties of Methyl Acrylate-Resin-Styrene System

Methyl Acrylate is a clear colorless liquid having the characteristic acrylic odor. It is very reactive in the presence of persulfate or peroxide catalyst systems and may be homopolymerized or copolymerized with other monomers. Prior to this work MA has been used principally as a monomer in thermoplastic polymers to form films and coatings with good light stability and water resistance.

Table 3. Index of Refraction of Methyl Acrylate-Polyester-Styrene Castings

Resin, %	Styrene, %	MA, %	Index of Refraction
80	20	0	1.564
80	15	5	1.560
80	5	15	1.552
80	0	21	1.544
"E" Glass			1.548

Index of Refraction. Methyl Acrylate has an index of refraction of 1.402 in the liquid state. In a polymerized MA-resin-styrene system increasing percentages of MA lower the index of refraction of the system to where it approaches that of "E" glass. *Table 3* shows the results of tests carried out on clear castings of nominal 0.060 inch thickness. It becomes apparent that laminates with increased amounts of MA should have greater clarity as the indices of refraction of the resin system and the glass more nearly approximate each other.

Table 4. Viscosity of Methylacrylate-Resin-Styrene Systems

Temp., °F	Resin, %	MA, %	Styrene, %	Viscosity, cps
77	90	10	—	530
77	85	15	—	265
77	80	20	—	135
77	85	—	15	355
77	80	—	20	220
70	80	5	15	250
77	80	5	15	180
85	80	5	15	170
70	80	10	10	250
77	80	10	10	165
85	80	10	10	150
70	80	15	5	250
77	80	15	5	150
85	80	15	5	130

Density. Liquid MA has a density at 77°F. of 8.0 lb./gallon. When used in a polyester-styrene system, increasing percentages of MA decrease the density of the resin system. *Figure 5* shows the effect of MA addition on a liquid resin system.

Viscosity. Liquid MA has a viscosity at room temperatures of approximately 0.5 centipoises. The addition of MA to a polyester-styrene system lowers the viscosity of the resin mix in most cases. Results of tests using a Brookfield Viscometer are given in *Table 4* and in *Figures 6 and 7*. In *Figure 6* it will be noted that below 70° increasing percentages of MA have no effect on the viscosity of the mix. In this instance, the use of increased percentages of MA may or may not

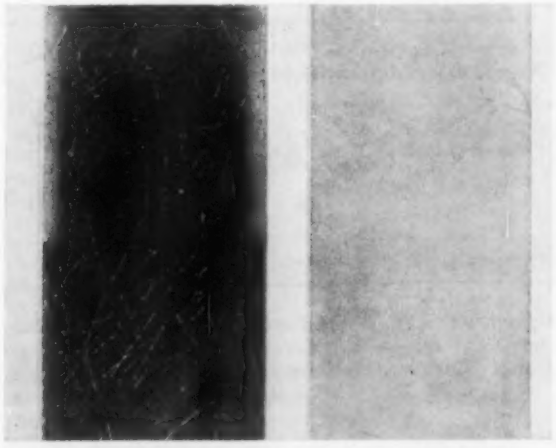


Figure 3. Polyester Laminates after 2500 hours Weatherometer Exposure
Styrene-Polyester Laminate (left)
Methyl Acrylate-Styrene-Polyester Laminate (right)

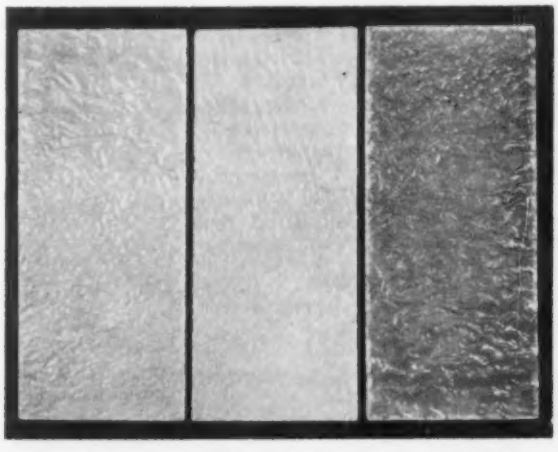


Figure 4. Polyester Laminates after 1800 hours Weatherometer Exposure
MMA-Styrene-Polyester Laminate (left)
Methyl Acrylate-Styrene-Polyester Laminate (center)
Styrene-Polyester Laminate (right)

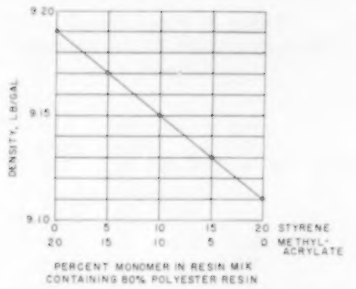


Figure 5. Density of Methylacrylate-Styrene-Resin System

be advantageous depending upon the application. Lower viscosity means better wetting of the glass mat or cloth, but conversely means poorer retention of the resin. Resin retention is quite often critical in commercial practice and should be investigated more thoroughly for the particular application.

Gel and Cure Characteristics. The MA used in this work contained 0.02 percent by weight of methyl ether hydroquinone as an inhibitor to prevent spontaneous polymerization. To determine the effect of this inhibitor and the MA itself on curing properties of the polyester resin system, gel tests were conducted according to the following procedure: A 100 gram sample is prepared in a 150 ml beaker. The beaker is placed with the level of the resin at the level of the heating liquid in a glycol bath maintained at 150°F, and the sample is stirred with a thermometer for the last five seconds of every thirty seconds making approximately fifteen revolutions. The temperature of the sample is read after alternate stirring periods (every minute). The gel time is the time at which the resin sample becomes rubbery to the extent it snaps back from the glass thermometer when it is inserted and withdrawn from the resin mass. After gel a thermopencil assembly fitted with a cap or plug to fit the beaker is inserted. The thermopencil is positioned so that it is centered and the tip is 5/16 off the bottom of the beaker. The position is

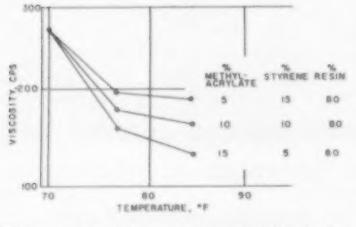


Figure 6. Viscosity of Methylacrylate-Styrene-Resin System

Table 5. Cure Characteristics of Polyester Resin Using Methylacrylate

Resin %	MA %	Styrene %	CHP %	BPO %	Gel Characteristics Time (min.)	Gel Characteristics Temp. (°F.)	Exotherm Characteristics Time (min.)	Exotherm Characteristics Temp. (°F.)
80	0	20	0.5	0.1	7′20″	148	16′30″	359
80	5	15	0.5	0.1	8′45″	147	17′30″	350
80	10	10	0.5	0.1	9′30″	148	18′45″	375
80	15	5	0.5	0.1	10′45″	149	20′15″	379
80	18	2	0.5	0.1	11′15″	150	21′00″	375
80	0	20	0.3	0.5	10′10″	149	19′45″	371
80	10	10	0.3	0.5	12′10″	151	20′45″	347
80	0	20	0.4	0.7	8′15″	147	15′30″	378
80	10	10	0.4	0.7	10′30″	147	18′00″	352

Table 6. Transverse Load Strength of Corrugated Reinforced Plastic Panels Using Methylacrylate Monomer

Panel No.	Monomer Composition* Styrene, %	MA, %	No. of Specimens	Weight, oz./ft. Range	Transverse Load lb./ft. Range	Avg.
1	10	10	3	8.0-8.2	350-575	452
2	10	10	3	7.4-7.7	286-465	367
						409
3	20	-0-	3	8.0-8.2	210-438	331
4	20	-0-	3	7.6-7.7	309-333	320
						326

* All panels made with 80% polyester resin, 20% monomer.

Table 7. Bearing Strength of Corrugated Reinforced Plastic Panels Using Methylacrylate Monomer

Panel No.	Monomer Composition* Styrene, %	MA, %	No. of Specimens	Thickness Range, In.	Bearing Strength, lb. Range	Avg.
1	10	10	3	0.053-0.061	296-335	315
2	10	10	5	0.052-0.061	263-284	274
						294
3	20	-0-	5	0.057-0.060	230-270	245
4	20	-0-	5	0.060-0.063	210-290	255
						240

* All panels made with 80% polyester resin, 20% monomer.

important to insure uniform readings of exotherm temperature. The temperature is recorded every minute until the exotherm temperature is reached.

The results of these tests are given in *Table 5*. It is apparent that the use of MA with 0.02 percent methyl ether hydroquinone lengthens the gel and exotherm time but does not affect the interval from gel to exotherm. Whether these changes in cure characteristics are critical would require evaluation for the particular process and catalyst formulation. It is important to note that adjustments in cure condition are practical by catalyst adjustment.

Commercial Panels

Based on the results obtained on the laboratory test laminates, trans-

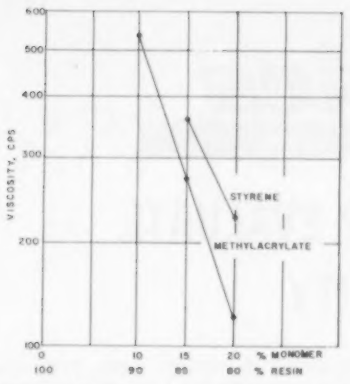


Figure 7. Viscosity of Monomer-Resin Systems at 77°F

lucent glass fiber reinforced panels were produced by a panel manufacturer in accordance with their normal procedure. Properties of these panels were measured in comparison to standard styrene modified polyester panels. The preceding preliminary tests indicated that an 80/10/10 resin-styrene-MA mix was most desirable from a production standpoint and yet would result in a panel with improvement in light stability, weathering and physical properties. Consequently, all panels used in these tests were of this combination. These panels were produced using two-ounce chopped strand fiberglass mat in 2⅛ inch standard corrugated panels. These tests are useful in evaluating the as-used properties of the panels although the numerical answers may not directly be convertible into absolute physical properties.

Transverse Load. The transverse load was measured in accordance with ASTM D1502-57T (Transverse Load of Corrugated Reinforced Plastic Panels). In this test, specimens 30 inches long are supported on two-foot centers. A load is applied hydraulically to the quarter points of the sheet. Three specimens were cut from each of four, twelve foot long corrugated panels. *Table 6* gives the results of these tests indicating that an increase in strength of approximately 30 percent is gained through the use of the MA.

Bearing Strength. The bearing strength was measured in accordance with ASTM D1602-58T (Test for Bearing Load of Corrugated Plastic Panel). In this test, a ¾ inch diameter steel pin is inserted in a slightly oversized hole and the force required to pull the pin ¼" through the panel is measured. Specimens were prepared in accordance with the test method from both the crowns and the valleys of the corrugations. The results of these tests are given in *Table 7*. The increase in strength here is not as apparent as in transverse load tests but still a gain in strength of over 20% is obtained.

Load Strength. The load strength or load carrying ability of the panels was measured by installing the panels on a steel test frame and loading uniformly with sand bags. In this test, a 6' long, 2⅛" corrugated panel, 26" wide was supported edges down on steel channels having a 4' clear span. ⅝" diameter holes were drilled through the top of the first, third, fifth, sixth, eighth and tenth corrugations and the panel was fastened with ⅛" steel building straws. A steel capped neoprene washer was used with each fastener. Bags of sand were applied to the panel at the rate of one, forty-pound bag of sand every minute until a uniform load of 75 pounds per square foot had been applied. At this point a 20-pound bag of sand was applied every three minutes until failure. The panel is considered to have failed when it collapses or when a tear of more than 2½" of length occurs in any one fastener or when two or more of the fasteners pull through the sheet. The results of these tests are given in *Table 8*. In those tests where no failure is indicated, it is due to a shifting and falling off of the load or insufficient additional load available for the test. Even including the tests where no failure was obtained (thus biasing the average toward the low values) an increase of almost 50% in strength was obtained.

Table 8. Load Strength of Corrugated Reinforced Plastic Panels Using Methylacrylate Monomer

Panel No.	Monomer Composition* Styrene, %	MA, %	Weight, Oz./Sq.Ft.	Load Strength Lb./Sq.Ft.
1	10	10	7.0	212
2	10	10	7.1	239
3	10	10	8.1	179 N.F.**
4	10	10	8.1	207 N.F.**
5	10	10	7.1	161 N.F.**
				200
6	20	-0-	8.1	126
7	20	-0-	7.3	127
8	20	-0-	7.7	167
				140

* All panels made with 80% polyester resin, 20% monomer.
** No failure at loads indicated. Tests discontinued due to shifting loads or lack of additional weights.

Summary

The laboratory results indicate that addition of methyl acrylate will increase the light stability and weather resistance of polyester resin laminates. Continued evaluation of these properties based on long term outdoor exposure will be needed to substantiate these tests and this work is now being conducted. The increased physical properties obtained with the MA modified laminates are based on limited tests on laminates with relatively low glass content. Whether similar improvement in physicals would be obtained with resins and glass contents designed for high strength laminates requires further investigation. Based on the data presented methyl acrylate should be considered as a polyester resin modifier for applications involving light stability, weather resistance and moderate strength.

Acknowledgment

The author wishes to acknowledge the cooperation of the Celanese Corporation of America for supplying the methyl acrylate for evaluation and conducting many of the tests in their laboratory; and the Alsynite Division of Reichhold Chemicals, Inc. for producing and supplying the corrugated panels.

Edited by
George Lubin,
Grumman Aircraft Co.

DOW Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

ACCELERATED AGING TESTS HELP EVALUATE PLASTICS' WEATHERABILITY

The weatherability of plastics materials is most accurately determined by exterior exposure testing. However, accelerated (machine) aging is often valuable for initial screening, and usually a correlation of results between outdoor and indoor testing can be established.

In selecting plastic materials for engineering use, major considerations are maintenance of adequate strength and acceptable appearance. Both properties are degraded during weathering, a complex process involving interactions of sunlight, air, humidity, wind, rain and heat. Since the full effects of variable climates cannot yet be duplicated in the laboratory, outdoor testing is carried out at stations where extreme weather conditions are the rule. Fig. 1 shows the relative effects of outdoor exposure on three different Dow polyethylene formulations.

Accelerated aging (or weathering) test equipment is designed to accelerate the rate of aging – that is, to produce the same effects as the normal aging process in considerably less than normal time. Two widely-used devices are the "Fadeometer" and "Weatherometer." The Weatherometer uses a carbon arc with intermittent water spray; the Fadeometer an arc only.

An S-1 sunlamp is also valuable for conducting laboratory aging tests. Fig. 2 shows relative severity of accelerated aging equipment. Initial evaluation of Dow plastics is first made in the Fadeometer. Materials which retain good strength and appearance after 2000 hours in the machine are considered suitable for further testing outdoors.

In evaluating Zerlon® 150, a new Dow plastic, exposures were made in the Fadeometer, in Florida and Arizona. Changes in luminous transmission were plotted at varying time intervals for each exposure station. It was found that 1600-1800 hours in the machine produce the same effect on luminous transmission as one year of weathering at the outdoor stations. Similar relationships were found for certain other properties–such as impact strength – but without an across-the-board correlation. Although such relationships are close approximations, weathering data are still required.

It is possible to predict weatherability in areas having different climates by using a measure of langley units (actinic radiation of one gram calorie per cm^2). Exposures are first conducted in a selected area and property losses established as a function of the number of langleys (amount of incident light energy). Then, on a basis of pre-set requirements for residual strength and appearance, service life of the plastics material in other areas can be predicted by determining relative langley ratings for those areas.

Most plastics have good aging characteristics for indoor use. The two most significant factors in degradation are heat and light. For heat, the most important consideration is a safe continuous operating temperature. The effects of light are more varied, with the rate of degradation increasing as ultraviolet energy content rises. Neither incandescent nor fluorescent light degrades plastics appreciably under ordinary conditions, but even filtered sunlight contains relatively damaging UV levels, depending on severity of the climate.

Germicidal ultraviolet lamps commonly used in appliances can be harmful to component plastic parts. UV radiation is relatively intense, and the extent of damage encountered will depend on type, size and location of the bulb, and also the type of plastic chosen. Studies on property retention and light stability should be conducted with prototype parts prior to settling on a final material and finished design for full scale appliance production.

Dow Plastics Technical Service Engineers work with designers and plastics engineers, assisting in materials selection and providing information on design, molding and finishing of plastic parts. Also available are detailed data from continuing Plastiatrics Studies on weathering and aging of plastics materials. For these data, and for information on Dow plastics, write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Dept. 1804EX10.

FIG. 1 RELATIVE EFFECT OF OUTDOOR EXPOSURE ON POLYETHYLENE FORMULATIONS

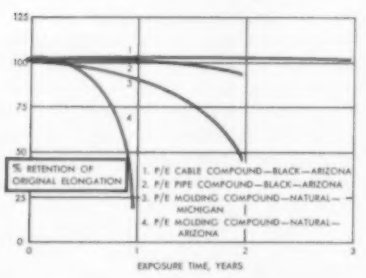
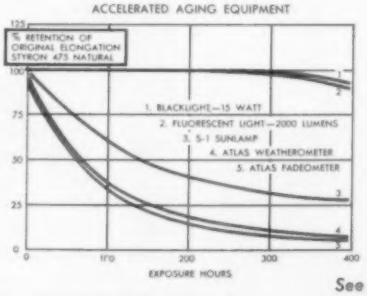

% RETENTION OF ORIGINAL ELONGATION
1. P/E CABLE COMPOUND—BLACK—ARIZONA
2. P/E PIPE COMPOUND—BLACK—ARIZONA
3. P/E MOLDING COMPOUND—NATURAL—MICHIGAN
4. P/E MOLDING COMPOUND—NATURAL—ARIZONA
EXPOSURE TIME, YEARS

FIG. 2 RELATIVE SEVERITY OF ACCELERATED AGING EQUIPMENT



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STANDARDS FOR PLASTICS

Advances in Vinyl Plastics Test Methods

Test methods for PVC show a decided trend with an emphasis on permanence characteristics. Activity is centered on tests for resistance to the effect of heat, light, microorganisms and the interaction of vinyls with other materials such as hydrogen sulfide, rubber compounds, organic finishes and metals.

This article reviews the current status of a number of vinyl plastics test methods that are being developed or have been recently adopted by ASTM. Attention is primarily directed toward methods applicable to flexible, plasticized compositions of poly (vinyl chloride) resin.

The primary responsibility in ASTM for developing plastic test methods is vested in Technical Committee D-20 on Plastics. The work in this committee is divided among 16 subcommittees, of which 8 are devoted exclusively to general test method development. The principal activity of the others is preparing specifications, but where a test method is specific to a plastic, these subcommittees may also undertake their own test development. The data used in this article were furnished by the various sections and task groups of the technical committees involved. For convenience, the titles and chairmen of these groups and sections are listed together at the end of the article. The author assumes full responsibility for the selection of the material presented and the interpretation thereof, and the reader should fully appreciate that the latter may not agree with eventual ASTM action on methods still in the development stage.

Test methods for plastics, where they are concerned with wire and cable insulation, may also originate in Technical Committee D-11 on Rubber and Rubber Products (3). At the present time, a joint D11/D20 task group is investigating one of the oldest and most troublesome tests with respect to reproducibility, that of air-oven aging.

Air-Oven Aging

The poor reproducibility of air-oven aging tests has been a problem of long standing in the vinyl industry. The degree of retention of tensile properties after aging has been used as a measure of the relative aging properties of vinyls and as a means of establishing their service temperature rating by Underwriters' Laboratories, Incorporated (11). Air-oven aging is a technique borrowed from rubber technology, and the test is made in an air circulating oven conforming to the requirements of ASTM Designation D573-53 (4). Maximum limits of temperature variation in this oven are ±2C, but there is no control of air velocity. Where volatilization of a plasticizer is involved, as with flexible vinyls, this can be an important variable. Just how critical this factor

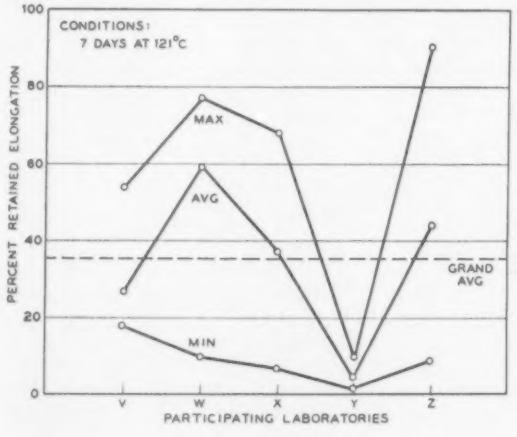

Figure 1. Circulating air oven aging of PVC wire insulation. Scattered data are results of first D-11/D-20 round robin test

Figure 2. Practical Royen tube oven for aging vinyl plastics.

is may be seen by referring to *Figure 1*. These scattered data are the results of the first round robin conducted by the D-11 task group charged with investigating this method. Very poor reproducibility was obtained between the five participating laboratories, with averages varying around the over-all average by as much as ±25% of the retained elongation.

A practical tube oven designed by Royen (10) was brought to the attention of the task group. Existing D573 ovens may be readily converted to this type of oven which explains one of the reasons for its appeal. The reproducibility reported for this oven was so impressive that a number of laboratories modified their ovens to duplicate this apparatus. Its most important feature is that each tube has the same air velocity; the adjustment in velocity being made by a damper at one end. A front view of this apparatus is shown in *Figure 2*. Tube or cell type ovens are not a new idea, and an ASTM specification for one is given in E95-58T (4). Because of the elaborate design of such models and the loss of oven investment that would be entailed by switching to them, industry has never shown much enthusiam for this apparatus.

A summary of the results of a second round robin using the Royen oven shows at an air velocity of 400 ft./min. a variation of ±15% for the average retained elongation around the over-all average, and at 800 ft./min. a variation of about ±10%, see *Figure 3*. This represents a considerable improvement in reproducibility over that obtained with the D573 type oven.

Both the first and second round robins were conducted so that the ovens were the only major variable. The material tested was an extruded 90C type black vinyl didecyl phthalate plasticized insulation furnished by one producer. The insulation was extruded on No. 16AWG solid copper conductor to a 1/32 inch wall. In performing the heat aging test, the conductors were removed from the insulation and the ends plugged with short lengths of conductor. To eliminate the testing variable, all aged specimens were sent to a central point for testing. Although this study was made on wire insulation, equally satisfactory results have been obtained with dumbbell specimens from pressed sheet. (10)

A disturbing factor that remains in the tube oven test is the wide range between maximum and minimum values in a single set of values. Exploratory experiments are in progress to find a means of reducing this spread. One procedure being studied is to incline the specimens at a slight angle in the tube. *Although there are still problems to be solved, the tube oven in its present form represents a long step forward in air oven aging.*

with plasticizers known to differ with respect to volatility and migration properties. The plasticizers used were octyl diphenyl phosphate, di-2-ethylhexyl phthalate (DOP), and a viscous polyester resin. The compounds were mixed according to the base formulation given below:

	Parts by Weight
Poly (vinyl chloride) Resin	100
Plasticizer	50
Dibasic Lead Stearate	0.25
	150.25

The principal effect of the cage was to markedly reduce the volatile loss. Referring to *Figures 5 and 6*, it may be seen that the cage does not appreciably change the relative order obtained with DOP or the 2-ethylhexyl

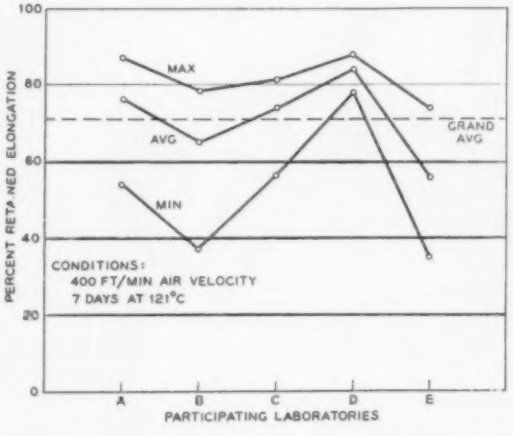

Figure 3. Royen oven aging of PVC wire insulation — didecyl phthalate plasticized PVC. This was second D-11/D-20 round robin, April 21, 1960

Carbon Volatility Test

A new procedure for performing the activated carbon volatility test on plastics has been introduced by the International Organization for Standardization (ISO) in Draft Recommendation No. 191 (2). This method offers two procedures, one of which is similar to that in ASTM D1203-55, where the specimen is in direct contact with activated carbon (4), and an alternate procedure, which is new, in which the specimen is enclosed in a wire screen cage. Presumably the cage, see *Figure 4*, is intended to eliminate the possibility of liquid migration, which has been a criticism aimed at the method.

An investigation has been undertaken in D-20 to determine the effect of the cage on volatile loss while varying temperature, specimen thickness and composition. The effect of composition was studied using three experimental compounds formulated diphenyl phosphate compounds at the thicknesses and temperatures tested. As far as these plasticizers are con-

Figure 4. Wire screen cage for enclosing specimen for activated carbon volatility test

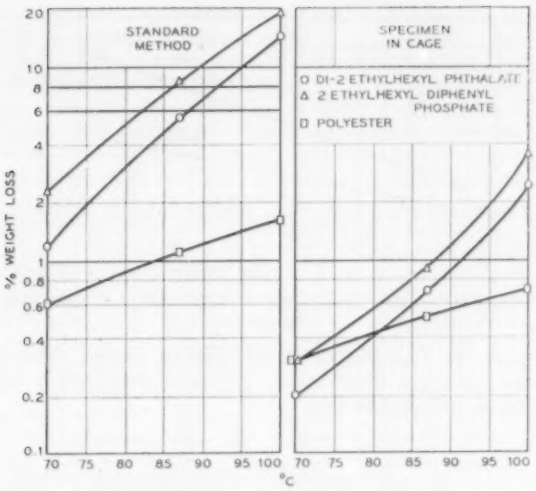

Figure 5. ASTM designation D1203-55. Volatile loss from PVC—0.01" sheet, heated 24 hours

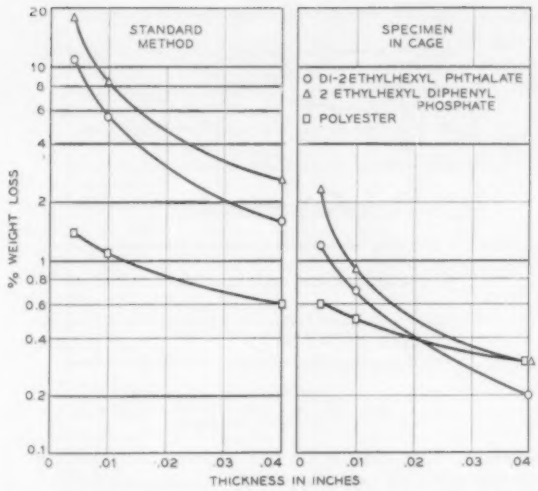

Figure 6. ASTM designation D 1203-55. Volatile loss from PVC—87°C for 24 hours

cerned, the only effect the cage has had is to reduce their rate of loss. The generally higher migration tendencies of the phosphate plasticizer does not appear to particularly affect its rating whether tested in direct contact with the carbon or in a cage. The polyester in the standard method shows losses well below the monomeric plasticizers which corresponds with experience for such materials. This order is maintained in the cage test except for the lowest losses where experimental error may be obscuring the true situation. On the basis of these data, there seems to be little argument in favor of the use of a cage in place of or as an alternate for the present standard ASTM D1203 method.

Microorganism Attack

Another permanence aspect of vinyls is their resistance to attack by microorganisms. Vinyl plastics may vary widely in this respect when exposed to environments that encourage biological activity, and a test for prescreening materials is needed. The loss of appearance that results from fungal activity on the surface of a plastic is well known, but what is less appreciated is that mechanical properties might also be lost from such an attack. This has been thoroughly investigated by the Army Quartermaster Corps, who have shown that fungi will stiffen and embrittle compounds containing certain types of plasticizer (8). Microorganisms reportedly destroy plasticizer by utilizing the carbon in its chemical structure for their metabolism.

Recommendations for writing a test method for the effect of microorganisms on plastics were solicited at a meeting held at ASTM Headquarters on January 29, 1958. The meeting was arranged by L. Boor, and microbiologists experienced in deterioration, representing both industry and government agencies, were invited to attend. In the opinion of this group, a plate type test employing a mineral salts nutrient agar would serve best. They were also of the opinion that there should be procedures for making tests with both fungal and bacterial cultures. The point was also made that a bacterium might attack a substrate without noticeable effect on its appearance, which emphasizes the need for mechanical or other evaluation than visual. Taking the suggestions that were made, a method was drafted that has been approved for D-20 letter ballot.

An example of the effect that was obtained on a molded sheet of a wire insulating compound, when tested for fungus resistance in accordance with the proposed ASTM procedure, is shown in *Figure 7*. The specimen used in this experiment is the new microtensile specimen per ASTM Designation D1708-59T, which may have a minimum length of 1.5 inches (4). Both specimens were started on the mineral salts nutrient agar; one was inoculated with the specified mixed spore suspension, and one held as a control. The dark growth on the inoculated specimen is evidence that attack has taken place, and the effect on tensile properties after 3 weeks incubation is shown in *Figure 8*. As a result of the attack, the plastic lost most of its reversible elasticity and became stiff with a sharp yield point and elongated as a result of plastic flow. The organisms used in the mixed inoculant were as follows:

Aspergillus niger
Trichoderma T-1
Aspergillus flavus
Pullularia pullans
Penicillium leteum
Aspergillus versicolor

The procedure recommended for determining bacterial resistance con-

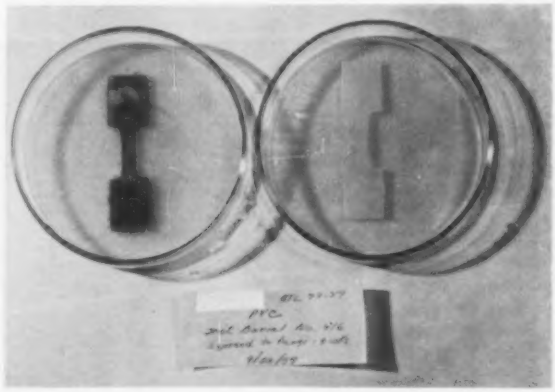

Figure 7. Microorganisms attack sample, left, with control at right. Sample was a molded sheet of wire insulating compound.

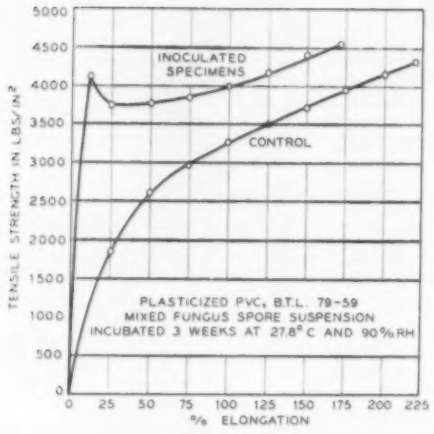

Figure 8. Test results on the resistance of plastics to microorganisms, obtained with proposed ASTM test method

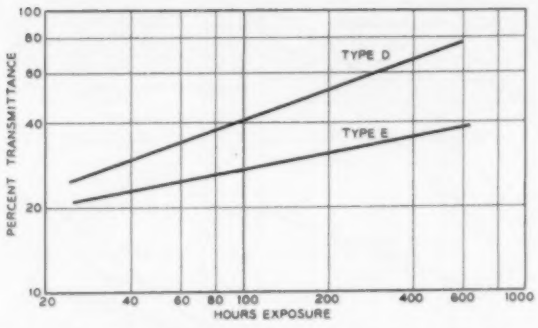

Figure 9. Transmittance of yellow plastic fading standard after exposure in artificial weathering apparatus per ASTM E42.

tained a single pure culture of *Pseudomonas aeruginosa*. This selection is being currently reviewed as the use of this bacterium has been questioned because of its possible toxicological hazard to laboratory personnel. The method as written is explicit, however, in stating that only biologically trained personnel should perform procedures involving the handling of organisms and inoculated specimens.

A troublesome effect in vinyls known as "pinking" may be produced, according to Girard and Koda (7), by a species of *Penicillium* in acid environment. Recently we were faced with this phenomenon in the development of a sponge vinyl earpad for telephone headsets. After two weeks of use, the natural ivory colored pads took on a distinct pink hue. An attempt to duplicate this with the ASTM fungi and bacterium cultures was not successful. Luxurious growth occurred with some yellowing and darkening of the plastic but no "pinking". This matter requires further investigation; for if it can be verified that a particular species of fungus will cause this effect, it might be desirable to have it included in the mixed spore suspension.

Light and Weather Resistance

Light. Light resistance is a critical property of vinyl plastics, and improving the standardization of artificial light sources for this type of test would represent an important benefit. The frequent disagreement between light aging tests made in different pieces of apparatus of the same design is well known. The American Association of Textile Chemists and Colorists (AATCC) have a blue paper standard, available through the National Bureau of Standards, for the calibration of light sources (1) (9). This method has as its basis the production of secondary standards as light-totaling devices in artificial aging equipment. Because of its short exposure life, about 24 hours, and its disintegration by water, the paper standard is not particularly suitable for plastics testing. To overcome these shortcomings, a new plastic fading standard has been developed which is described in a proposed "Recommended Practice for Determining Exposure Conditions in Artificial Weathering Apparatus".

The new standard is based on the controlled rate of fading of a yellow dye in poly (methyl methacrylate). The yellow plastic is prepared from poly (methyl methacrylate) meeting ASTM Specification D788-56T, Grade 8 with no ultraviolet absorber (4), and Solvent Yellow 33C.I. 47,000 (6) The fading standards are made with an original transmittance of 17±1% at a wavelength of 420 millimicrons for a thickness of 0.125" using the necessary concentration of the dye. Where straight line plots of transmittance vs. exposure are obtained, see *Figure 9*, it should be possible to characterize a light source by stating the slope. In practice it will be necessary to have a portion of each batch of yellow plastic standardized in a master lamp by exposing it to a convenient measured light dosage; the yellow plastic then becomes the secondary standard used to gage the light dosage in other lights. It is hoped that when more data is available that it will also be possible to extend the recommendation of this fading standard to outdoor weathering.

Outdoor Weathering. What has been said above regarding light aging of vinyls also applies to their exposure outdoors. This type of testing also serves as an important means of observing attack by microorganisms which may grow profusely on samples exposed to a tropical climate. Such growth is almost never seen on samples exposed in artificial weathering apparatus which is one reason why complete correlation between artificial and outdoor weathering cannot be expected.

To obtain comparative outdoor data, samples must be exposed in a uniform manner, and the "Recommended Practice for Outdoor Weathering of Plastics", D1435-58 has been adopted for this purpose (4). A uniform angle of 45 degrees is specified, and the preferred method of mount-

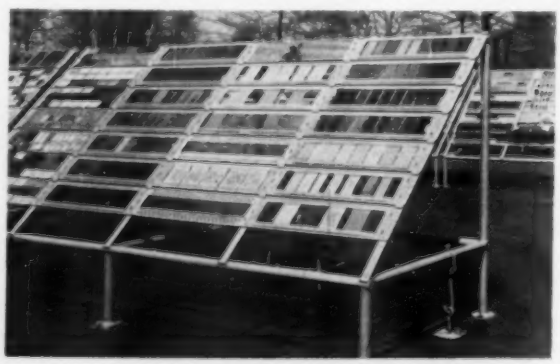

Figure 10. Outdoor display rack having uniform angle of 45 degrees. The frames support the samples without backing

ing specimens is on a frame that supports the specimens without backing. An example of a rack displaying the recommended mounting is shown in *Figure 10*. The decision to use a 45 degree rack was largely based on results obtained with natural polyethylene which showed that the angle of exposure was not critical over a fairly wide range of 15 to 60 degrees.

Interaction With Materials

Test methods for evaluating resistance to staining and migration are receiving increasing attention as vinyls are brought into contact with a greater variety of substances. These may be in the form of solids, liquids or gases. One of the commonest and best understood forms of staining is that produced by hydrogen sulfide. This gas reacts with many metallic ions to produce colored compounds which are objectionable because of the effect on appearance. Pigments and stabilizers are among the ingredients that must be chosen with care if sulfide staining is to be avoided. A new standard method for testing the resistance of a compound to this gas is available in ASTM Designation D1712-60T, Tentative Method of Test for Resistance of Plastics to Sulfide Staining.

Rubber Staining. This is a more difficult problem than sulfide staining because of the numerous possible sources of staining that may be found in a rubber compound. Antioxidants, accelerators, organic extenders and even the rubber elastomer itself may cause staining. The problem is highlighted at present by the effect of items such as rubber casters and rubber heels on vinyl floor tile. The problem, of course, is not all one-sided, and the plastics formulator has a responsibility to select ingredients, particularly plasticizers, that will retard migration. Among the environmental conditions that affect the development of staining are heat and pressure, and in some cases light is very important.

A test development program is in progress in Committee D-20 in close liaison with D-11. A preliminary round robin has been completed in which a number of rubber vulcanizates have been studied. On the basis of these results, which showed good agreement, a draft of a test method is being written that will undoubtedly require further interlaboratory evaluation.

Lacquer Mar. Pressure for the development of a lacquer mar test is beginning to be felt from ASTM Committee D-1 on Paint, Varnish, Lacquer and Related Products. The possibility of damaging the finish on furniture and other products through contact with certain types of vinyl plastics is becoming more generally recognized. A need exists for a standardized procedure for evaluating the marring tendency of a vinyl that may, in normal service, be regularly in contact with organic finishes. The problem is similar to that of rubber staining in that reference finishes for determining degree of attack will be needed which will require close cooperation with D-1 finish personnel. An active round robin study is in progress on this problem.

Corrosivity. Another form of interaction that directly affects the application of vinyls is their corrosivity toward metals. This is of particular concern in electrical applications where corrosion could reduce the effective cross-section of a conductor or impair the performance of delicate mechanical parts. Two methods have been considered for investigation: (1) an extract conductivity method and (2) a galvanic cell method. The first estimates corrosivity on the basis of the electrolytic conductivity of an aqueous extract of the ionic substances from a plastic. The second method determines corrosivity by measuring the current generated by a test cell comprising a sheet of plastic between two dissimilar metal electrodes in an H_2O saturated atmosphere. At present, attention is being given only to the galvanic cell method, and a round robin has been organized to investigate it.

Infrared Analysis

The ideal way to specify a material is by means of a performance specification. The test methods needed may, however, be prohibitive because of the excessive time required to execute them. This is particularly true, for example, in making plasticizer compatibility tests on vinyl plastics. This is where infrared analysis may be of assistance. By specifying a composition that experience has shown to be compatible and having a method of analysis for determining whether the product conforms, provides a rapid, indirect means of controlling compatibility and other associated properties.

An infrared analysis method proposed by the Northern Electric Company (5) is now being examined in round robin for accuracy and reproducibility. The method is a systematic approach to the identification of PVC resin, plasticizers, stabilizers and fillers in vinyl plastics. Complementary procedures such as chromatography and X-ray spectroscopy may be drawn on for more complete analysis. Three compounds of known composition have been sent to the 12 participating laboratories. Data from this project should prove very interesting when it becomes available.

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The experimental data presented herein represent the efforts of numerous members in the various sections and task groups of ASTM that participated in the projects discussed. The plastics industry owes these members and their sponsoring organizations a debt of gratitude for the service they have been performing in the development of improved standards. The author wishes to thank the joint task group of Subcommittees V and XV of Committee D-11, G. N. Vacca, Chairman (Bell Telephone Laboratories) for the round robin data furnished on air-oven aging. The author also wishes to acknowledge the contributions from the following sections of Subcommittee V on Permanence of Committee D-20 under the able Chairmanship of B. G. Achhammer (National Bureau of Standards): Section A, D. A. Hurst, Chairman (Rohm and Haas) for information on the plastic fading standard; Section B, P. R. Graham, Chairman (Monsanto Chemical Company) for data on the activated carbon test; Sertion J, A. Mendizza, Chairman (Bell Telephone Laboratories) for information on corrosivity test methods; Section K, N. L. Perry, Chairman (Argus Chemical Company) for reference to staining activities; and to Section M for data and the photograph (*Figure 8*) furnished by R. A. Conolly (Bell Telephone Laboratories) showing the effect of microorganisms on vinyl plastics. The infrared analysis program mentioned is being conducted by D-20 in Section H of Subcommittee VII under the leadership of D. N. Kendall (Kendall Labs.).

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SPE JOURNAL

Every Month—the *significant* NEWS
OF PLASTICS ENGINEERING

Long-Term Wet Strength of Polyester Resins

C. E. Loetel and H. E. Fordyce,

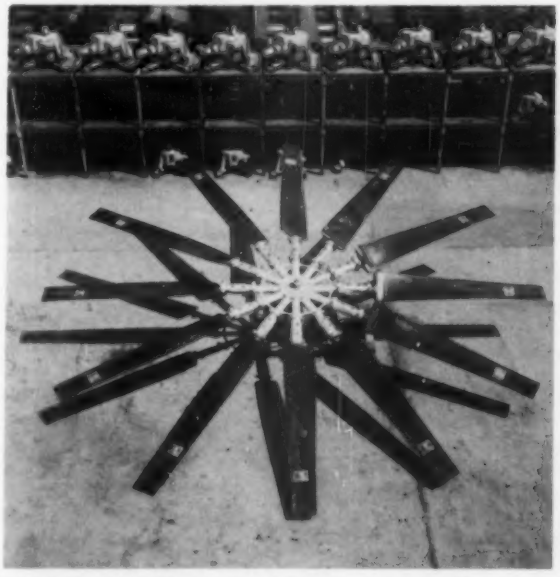
The Marley Co.

This article evaluates the wet-strength retention of glass-reinforced polyester laminates. Of particular significance is the indication that acid number of polyester resins is a quick way of judging long-term durability in water immersion.

There is little information contained in the literature on wet-strength retention of glass-reinforced polyester resin laminates. Some excellent work has been published (1,2) which covers short term exposure. However, these results cannot be extrapolated to predict long-duration performance. The test results reported in this article were obtained with polyesters of the unsaturated type copolymerized with styrene or vinyl toluene.

The Procedure

Accelerated tests were conducted by immersing the test samples in boiling water. Samples were prepared as follows: Resin free of pigment or filler was catalyzed and adjusted to a styrene content of 43%. Eight of the 12 plies of oven-dried Hess-Goldsmith 181/38-71 glass cloth with vinyltrichlorosilane finish was placed in a mold heated to 250°F. The catalyzed resin was poured onto the glass cloth. The additional four plies of glass cloth were laid on top and the press closed to 0.1 inch stops. Each panel was cured three minutes or until the part hardened. The finished laminates contained 31% resin (weight), 69% glass (also weight), 0.11 in. thick, and overall size 6x9 in. Test coupons 1½ x 5 in. were cut from the panels. Five coupons were obtained from each panel. One coupon from each of the three panels made constituted a test sample. The flexural strengths indicated in the test results are an average of three panels. All load tests were carried out at about 70°F. Coupons were brought to room temperature and kept moist by immersion in water until tested.



A 22′ diameter fan assembly composed of 12 glass-reinforced polyester fan blades, each of which weighs 50 pounds.

The tests were conducted in boiling water (as indicated above), 160°F, and exposure to steam at 10 psi. Flexural strength was determined at various intervals (*see Table 1*).

Isophthalic Polyesters Shine

At the beginning of the program, it was arbitrarily decided that any laminate losing more than 50% of initial flexural strength after 90 days in 200°F water would not be suitable for the appli-

Table 1. Resins Tested and Their Strength Retention (Flexural Strength in psi) in the Various Test Mediums

Catalyst: 1% BPO, 43% Styrene	Initial	Exposure—10 PSI Steam 64 Hrs.	128 Hrs.	256 Hrs.	512 Hrs.
Bisphenol Polyester A	40,000	37,000	34,500	35,500	30,000
Polyester Resin R	42,000	31,500	27,500	22,500	11,500
Polyester Resin G	47,000	36,000	32,500	26,500	21,000
Chlorendic Polyester	36,500	36,200	35,800	34,000	27,500
Polyester Resin A_7	44,000	38,500	37,500	32,500	31,500
Polyester Resin A_9	49,500	49,000	43,000	38,000	32,500
Polyester Resin U	41,000	40,500	37,500	36,000	33,000
Isophthalic Polyester C	47,500	44,500	41,500	39,000	36,000
Isophthalic Polyester D	41,500	40,000	41,000	34,000	34,000
Polyester Resin Hr	41,500	38,600	34,400	32,000	25,100
Catalyst: 1% BPO, 43% Vinyl Toluene					
Isophthalic Polyester D	40,000	39,000	37,000	36,000	32,000
Catalyst: 0.5% BPO, 0.5% DDM, 43.0% Styrene					
Polyester Resin AP	46,500	49,000	47,000	46,000	35,000
Isophthalic Polyester C	41,800	47,500	44,000	43,000	41,500
Isophthalic Polyester D	38,400	46,000	43,500	39,000	32,500
Bisphenol Polyester A	34,500	38,500	39,500	36,000	30,000
Polyester Resin Hr	40,000	40,000	36,500	32,000	24,800

Catalyst: BPO 1%, Styrene 43%	Exposure—200°F Water Immersion Initial Flex	30 Day	60 Day	90 Day
Isophthalic Acid Polyester D	45,000	33,000	24,000	20,000
Isophthalic Acid Polyester C	45,000	36,000	31,000	25,500
Phthalic Anhydride Polyester A_7	43,500	29,000	25,000	21,000
Low Density Polyester—Resin U	41,000	34,500	29,500	27,500
Chlorendic Acid Polyester	40,000	25,500		19,750
Phthalic Acid Polyester G	44,000	21,500		
Bisphenol Polyester	40,000	28,000	22,500	21,200
Catalyst: BPO 1%, Vinyl Toluene 43%				
Bisphenol Polyester	36,000	30,000	26,000	22,500
Isophthalic Acid Polyester D	40,000	30,000	23,000	21,500
Catalysts: 0.5% BPO, 0.5% DDM, Styrene 43%				
Bisphenol Polyester	37,500	35,000	32,000	31,000

Catalysts: 0.5% BPO, 0.5% DDM, Styrene 43%	Exposure—160°F Hot Water Initial	Days Immersion 90	180
Bisphenol Polyester A	33,000	32,000	33,500
Catalyst: 1% BPO, 43% Styrene			
Polyester Resin U	36,000	33,800	34,200
Isophthalic Polyester C	43,500	37,100	35,700
Polyester Resin RH	58,700	35,000	30,400
Polyester Resin G	51,500	43,000	33,000
Polyester Resin A_9	40,500	35,000	32,100
Isophthalic Polyester O_3	57,000	54,500	
Polyester Resin R	43,000		22,300
Isophthalic Polyester D	43,500		39,600
Bisphenol Polyester	41,000	31,700	34,400

cation required. Manufacturers were asked to submit laminates made according to MIL-R-7575A Specification. Later panels were manufactured in the laboratory, as described above. This was necessary because of the known variation in strengths caused by manipulation of resin and glass cloth prior to molding. The procedure used may not produce strengths in line with published results, but it does eliminate one big variable and duplicates more nearly a matched-die molding.

The 50% wet strength retention requirement eliminated almost all commercially available resins. It was about this time that isophthalic acid polyesters became available. Tests have shown that with isophthalic acid, some manufacturers have been able to produce resins with excellent physical properties. It is interesting to note that they have been able to do so at prices competitive with phthalic anhydride-based polyester resins. Not all polyester resins labeled to contain isophthalic acid have been equally good. One isophthalic polyester in particular was extremely weak initially and lost most of this strength in 30 days at 200°F in water. In addition to isophthalic acid polyesters, a few other polyester resins have held up well in long term water immersion.

One chlorendic acid based polyester and another based on Bisphenol A have shown good wet strength retention. These resins, however, are at present less attractively priced than the isophthalic based resins.

Catalysts Play Important Part

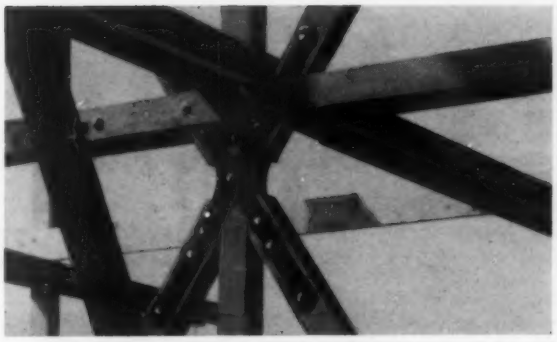
The Bisphenol-based polyester merits special mention because it is the only resin tested that has not continued to lose strength as the testing continues. This set of panels in 200°F water showed 93% strength at 30 days, 86% at 60 days and 84% at 123 days. This is exceptional. By using 0.5% DDM (methylethylketone peroxide) and 0.5% benzoyl peroxide in place of 1% benzoyl peroxide, a substantial increase in wet strength retention resulted. The role of catalysts was pointed out by H. J. Sang and associates, Stanford Research Institute. As will be noted in *Table 1*, this catalyst system is not equally effective for all polyester resins. It is interesting that with nearly all resins the mixed catalysts give an initial strength that is lower than with 1% benzoyl peroxide. The strength then increases during the early stages of testing before a decrease in strength begins. The entire field of catalysts, and perhaps inhibitors as well, needs to be explored in more detail. Another note of interest concerning the bisphenol polyester resin with 0.5% DDM and 0.5% BPO catalyst system was that it had a pot life at 70°F of over two months.

Several other resins of unknown composition have been tested and have good wet strength retention. However, in passing, it should be stated that in the final analysis a resin must be moldable. Several of the resins with good wet strength retention have had too low a heat distortion temperature or too long a cure time to be suitable for our use.

Information has been obtained that substitution of vinyl toluene for styrene in polyester resins has no effect on laminate strength. This is borne out by the results of these tests. In addition, the vinyl toluene has eliminated blisters that occurred in the parts made with styrene.

Phenolic-Epoxy Laminates

In addition to polyester resins, panels using a limited number of epoxy, phenolic, and combination epoxy-phenolic resins were also made. These have been made with a number of different hardeners. Some panels have shown high initial strengths but lost strength rapidly in water immersion at 200°F. These panels were made with glass cloth having a vinyl chlorosilane finish. To what extent this affects wet strength retention has not been determined.



A reinforced plastic connector part.

Resins tested and their strength retention in the various test mediums mentioned previously:

These test results bring up the subject of why one resin is more durable than another. Saponification, inhibitor type and concentration, melting point, and catalyst types and concentration, as well as the reacting constituents, were reviewed. Another possible criterion of polyester durability in wet-strength retention is acid number. To explore this briefly, acid numbers were determined on resins for which wet-strength retention data was available. With only one exception the resins with the lowest acid numbers had the highest wet strength retention *Table 2*.

Table 2. Acid Numbers of Polyester Resins. Low Acid Numbers Mean High Wet Strength

Resin	Acid No.	Flex. Strength in PSI After 500 Hrs. @ 10 PSI Steam
Isophthalic Polyester C	10	36,000
Isophthalic Polyester D	16	34,000
Polyester Resin U (Abetic Acid)	93	33,000
Polyester Resin A_p	20	32,500
Bisphenol Polyester	22	30,000
Polyester Resin A_7	29	31,500
Chlorendic Polyester	34	27,500
Polyester Resin G	38	21,000
Polyester Resin R	46	11,500

Conclusions

It has been shown that, in general, the isophthalic based polyester resins give a decided increase in wet strength retention over the average phthalic anhydride based resins.

One bisphenol based polyester resin and one chlorendic acid type resin gave good wet strength retention.

Literature References

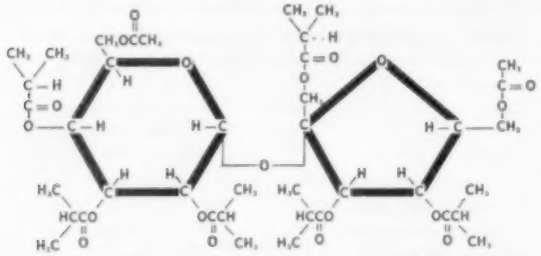
1. H. J. Sang, D.M. Coulson and B. M. Sifford, "High-Strength Plastic Laminates for Use in Aircraft H. F. Antennas", Stanford Research Institute. Prepared for Wright Air Development Center.
2. Edward G. Bell and Dr. Edward G. Bobalek, Case Institute of Technology, "Effect of Molecular Constitution of Polyesters on Steam Resistance of Polyester-Styrene Copolymers". *Proceeding of Paint Research Institute Official Digest*, P. 878-898, July 1959.

Sucrose Acetate Isobutyrate in Cellulose Acetate Plastics

Sugar derivative improves end product and processing characteristics of cellulose acetate resins

W. M. Gearhart and E. W. Wilson
Eastman Chemical Products, Inc.

This article outlines the properties of sucrose acetate isobutyrate (SAIB) and points out several of the advantages to be gained from its use in cellulose acetate plastics. A possible molecular structure of SAIB is shown below:



Note two acetyl groups, one at the right and the other at the upper left hand corner of the molecule, and six isobutyryl groups which have replaced the other hydroxy groups on the sucrose molecule.

Some Physical Properties of SAIB

Sucrose acetate isobutyrate is a water-white, viscous liquid with a molecular weight of 838. At temperatures above 70°C, viscosity is fairly low, being less than 1000 cps. Below 70°C, though, a sudden increase in viscosity occurs and at 50°, it increases to about 4500 cps. As the temperature decreases further, viscosity goes up, and the material has a glass-like consistency at the lower temperatures. SAIB does not form crystals.

Toxicity

Limited studies have been made of the toxicity of SAIB. In animal experimentation, no deaths occurred in rats or mice given either oral or intraperitoneal doses of 25,600 milligrams per kilogram of body weight administered in a 50% solution in corn oil. A 20% solution in a mixture of acetone and corn oil held in contact with the depilated skin of guinea pigs for a period of 24 hours caused practically no skin irritation and there was no evidence that the material was absorbed directly through the intact skin. It thus appears that no special handling precautions are necessary.

Lacquer Applications

The first applications for SAIB developed in the field of lacquers. The good compatibility of SAIB with a variety of film-forming resins suggested this application. Because of several advantages resulting from the use of this material in protective coatings, it has been finding increasing application in this field. One of the outstanding advantages from the use of SAIB is shown in *Figure 1*, a graphical representation of the effect of SAIB on the hardness of various polymer films as determined by the conventional Sward Rocker apparatus. Shown is the change in the surface hardness resulting from the incorporation of SAIB; first, in a Half-Second Butyrate film; next, in a cellulose nitrate film; and in the last two

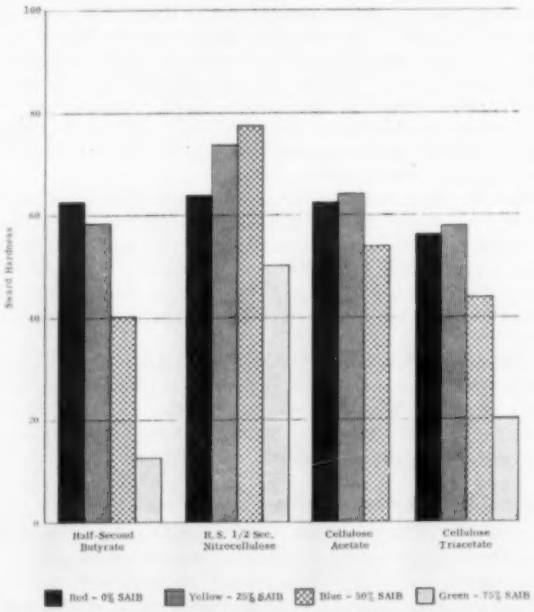


Figure 1. Effect of SAIB on Sward Hardness of various polymers

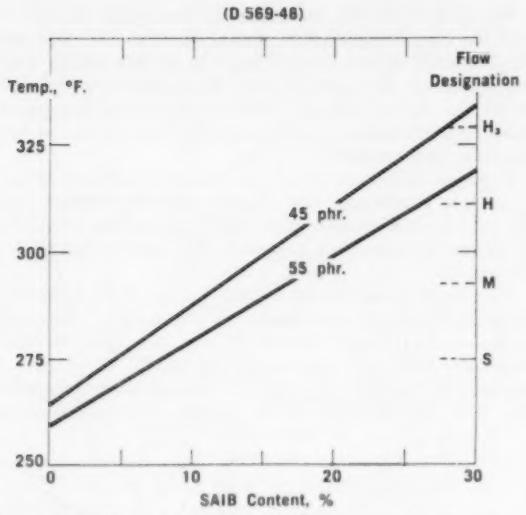


Figure 2. Effect of SAIB concentration on flow temperature of cellulose acetate plasticized with dimethyl phthalate

groups, in films of two types of cellulose acetate. Note that, in the nitrate and acetate films, the inclusion of SAIB increased the surface hardness of the films.

Consideration of its properties and lacquer applications shows that SAIB is a high-molecular-weight material which contributes an increased surface hardness to films and does this without sacrifice of hydrolytic stability or volatility. One additional point should be noted. Studies of lacquer applications indicated that SAIB was not a plasticizer for cellulose acetate by a strict definition of the word. It did not show a direct relation between elongation and concentration. It performed more in the role of an extender, exhibiting limited compatibility and use with cellulose acetates. Though for discussion purposes, deviation from the general plasticizer definition will be made and SAIB will be considered as a plasticizer.

Application in Cellulose Acetate Plastic

One of the most valuable applications for SAIB in cellulose acetate is in the field of dimethyl phthalate-plasticized materials. For some time dimethyl phthalate has given considerable trouble in the field of cellulose acetate because of difficulties in processing and later in the process of injection molding. It has been hypothesized that, if a material could be found which would minimize the solvent action of dimethyl phthalate without sacrificing permanence or volatility, an excellent cellulose acetate molding compound could be produced with this combination. In view of the performance of SAIB in other applications, it appeared to be a natural consequence that it should be evaluated in this type of system. It has been found well suited to this application. Evaluations have been made of the use of dimethyl phthalate and diethyl phthalate in combinations with SAIB in cellulose acetate plastic and the following series of illustrations shows the effect on the properties of the plastic when portions of the major plasticizer are replaced with SAIB. The cellulose acetate used in this case was E-394-30, which is a material containing approximately 39% acetyl or 55% combined acetic acid.

As shown in *Figure 2*, an increase in the SAIB content with a corresponding decrease in the dimethyl phthalate content at a total plasticizer concentration of 45 phr. (parts per hundred parts of resin) resulted in a gradual increase from an S flow up to an H3 flow at 30% SAIB. With a total of 55 parts of plasticizer, the initial plastic is slightly softer, but the increase in flow generally parallels that which occurred at 45 phr.

Figure 3 shows the effect of SAIB on tensile strength in these same formulations. As indicated by the upper curve at 45 phr. there was a gradual rise in tensile strength as the SAIB content was increased. At the 55 phr. concentration, the increase in tensile strength appeared to be a little more rapid at the higher SAIB concentrations, above 15%, than in the case of 45 phr. Generally, then, an increase in concentration of SAIB results in a slight increase in tensile strength.

Figure 4 shows the effect of SAIB on the Rockwell hardness of the cellulose acetate. A pronounced increase in hardness occurred as the SAIB content increased. In this case, as in previous cases, the 55 phr. concentration line closely parallels that of the 45 phr. concentration line.

The behavior of SAIB in dimethyl phthalate-plasticized systems with regard to accelerated aging losses is shown in *Figure 5*. The results obtained might have been predicted from a consideration of the molecular weight and volatility

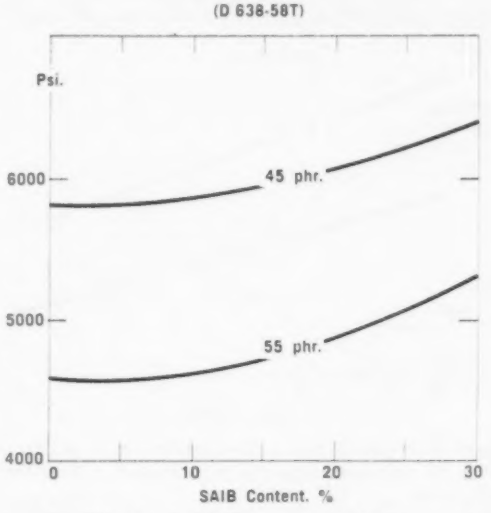


Figure 3. Effect of SAIB concentration on tensile strength of cellulose acetate plasticized with dimethyl phthalate

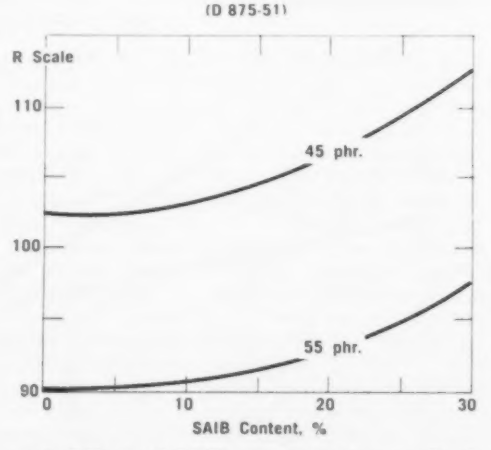


Figure 4. Effect of SAIB concentration on Rockwell Hardness of cellulose acetate plasticized with dimethyl phthalate

characteristics of SAIB. With the incorporation of increasing amounts of SAIB, a steady decrease in the weight loss resulted under the conditions of this test. Here again, values obtained with the two plasticizer concentrations generally paralleled one another over the range of SAIB concentration tested.

Izod impact strength decreased as the SAIB content increased, as shown in *Figure 6*. The line representing 55 phr. total plasticizer declines more rapidly than the 45 phr. line. These two lines probably would reach a minimum at some higher SAIB concentration and, although shown here as straight lines, they probably are not.

Thus far, only the use of SAIB with dimethyl phthalate has been considered. The use of SAIB with diethyl phthalate under the same conditions should also be considered. *Figure 7* shows the flow temperature versus SAIB content. These data fairly well approximate those shown on dimethyl phthalate and show a constant increase in flow temperature with increasing SAIB content. The values for 45 phr. and 55 phr. parallel one another closely.

Figure 8 shows the effect of SAIB on tensile strength. As with the dimethyl phthalate system, these values once again parallel each other closely. There is an increase in tensile strength at 45 phr. starting at the first introduction of SAIB. At 55 phr. the increase is a little more gradual, beginning a more rapid increase at 15% to parallel the values of lower plasticizer concentration.

Figure 9 shows the effect on Rockwell hardness of SAIB in acetate plasticized with diethyl phthalate. Once again, the curves parallel each other and indicate that an increase in SAIB concentration improves the surface hardness of the material.

Results of the accelerated aging test on diethyl phthalate-plasticized acetate are shown in *Figure 10*. The diethyl phthalate had a high loss at 55 phr. but this loss rapidly decreased with the introduction of SAIB. At 45 phr. the loss was correspondingly high but was reduced more gradually with the addition of the sucrose acetate isobutyrate.

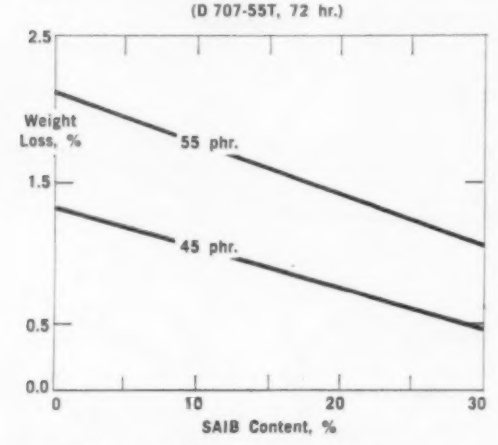


Figure 5. Effect of SAIB concentration on accelerated aging of cellulose acetate plasticized with dimethyl phthalate

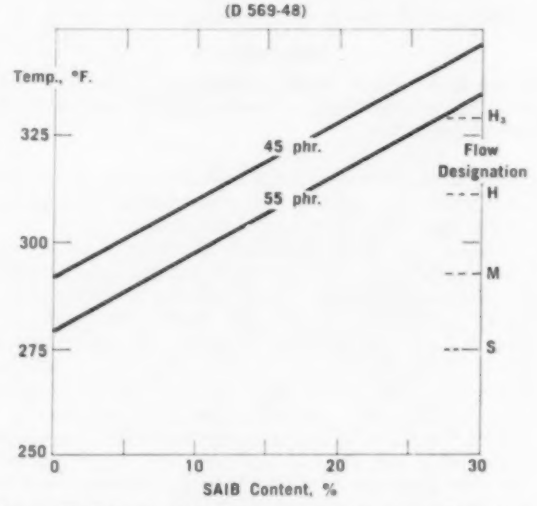


Figure 7. Effect of SAIB concentration on flow temperature of cellulose acetate plasticized with diethyl phthalate

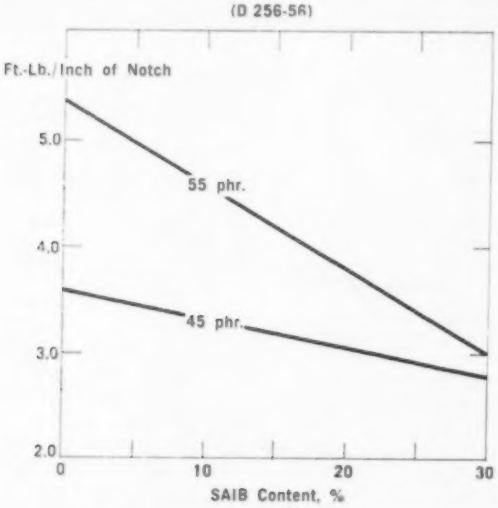


Figure 6. Effect of SAIB concentration on Izod impact strength of cellulose acetate plasticized with dimethyl phthalate

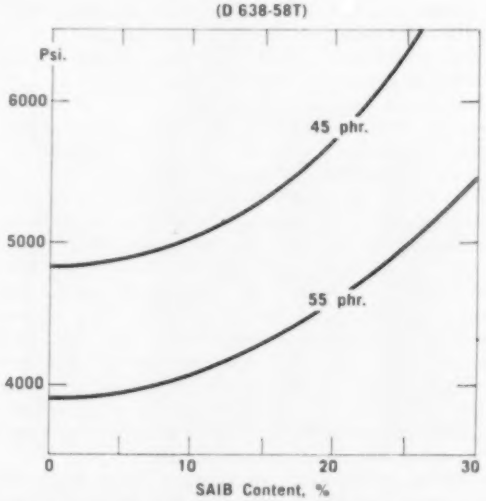


Figure 8. Effect of SAIB concentration on tensile strength of cellulose acetate plasticized with diethyl phthalate

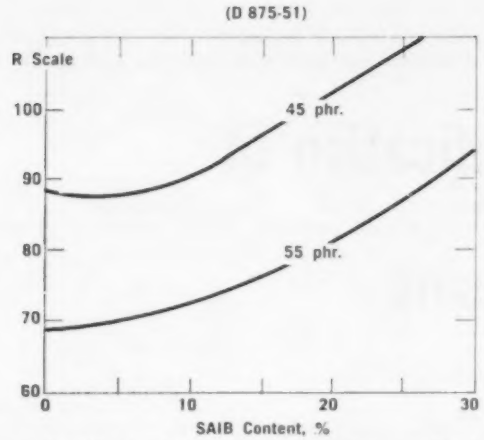


Figure 9. Effect of SAIB concentration on Rockwell Hardness of cellulose acetate plasticized with diethyl phthalate

These lines are probably approaching some asymptote which is far to the right at a higher concentration of SAIB.

Figure 11 shows the Izod impact strength of this system. At 55 phr., the Izod impact strength was quite high and diminished as the SAIB content increased. At 45 phr. the decrease was not quite as abrupt. Note that these two lines join at about 25% SAIB and probably have neared the asymptote which were mentioned in consideration of the dimethyl phthalate-plasticized materials.

Application

The properties detailed in the graphs indicate several types of applications for SAIB-modified cellulose acetate formulations. These formulations are varied and each one takes advantage of some particular property of SAIB. Consider, for example, the simple operation of dry-blending. In the prior processes, this operation with dimethyl phthalate was very difficult. At higher plasticizer concentrations, it was usually impossible. Now, through the use of SAIB, it is possible to deactivate the cold-solvent action of dimethyl phthalate and use this desirable plasticizer in acetate formulations. There is a practical limit to the concentration of SAIB which might be incorporated into cellulose acetate plastics. This limit appears to be approximately 15 parts per 100 parts of resin. Beyond this concentration, there appear

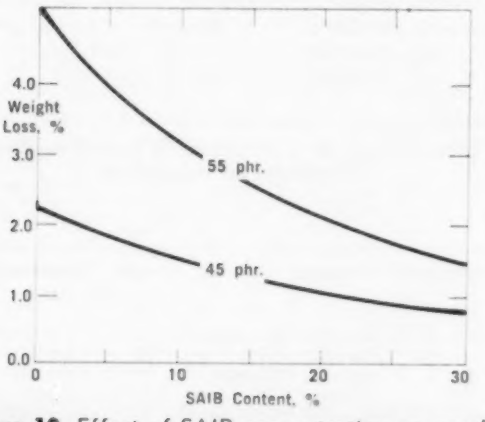


Figure 10. Effect of SAIB concentration on accelerated aging of cellulose acetate plasticized with diethyl phthalate

to be definite breaks in certain properties. Notable among those properties which drop off rapidly with increased SAIB concentrations is flexural modulus. In the case of diethyl phthalate, this decrease in flexural modulus is a very gradual process, but in the case of dimethyl phthalate, a sharp decrease occurs at a concentration of approximately 15 phr. SAIB.

In addition to the advantages to be gained in dry-blending, there are advantages to be gained in extrusion and molding operations. We have observed on extrusions that there is a more uniform feed through the cylinder when the SAIB-dimethyl phthalate systems are used. This is a considerable improvement over the straight dimethyl phthalate-plasticized systems. There is also an indication that SAIB contributes to the ease of molding of cellulose acetate by preventing the freezing of the melt during the molding operation. These phenomena are associated with the viscosity-temperature relation mentioned previously. It appears that the unique viscosity characteristic demonstrated by SAIB is to some extent carried over into the performance of the SAIB-modified cellulose acetate compositions. In addition to these effects, there has been observed a distinct advantage in hardness which cannot be gained by a decrease in

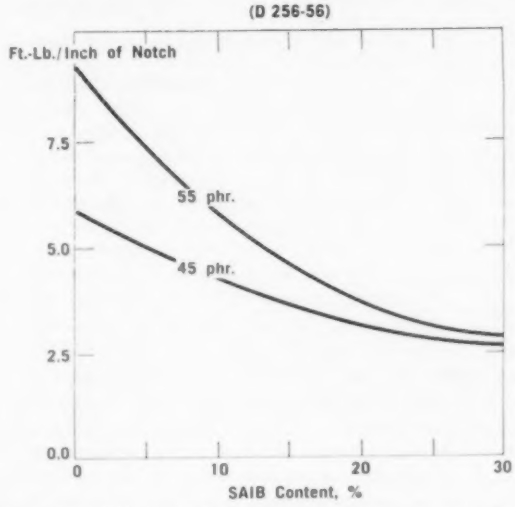


Figure 11. Effect of SAIB concentration on Izod impact strength of cellulose acetate plasticized with diethyl phthalate

plasticizer concentration. A high surface hardness can now be obtained while still maintaining a very practical flow temperature. This permits the processing of dimethyl phthalate-SAIB formulations in the range of H5 and H6, which was possible before only with extreme difficulty. The hardness characteristics of these flows can be achieved at a softer flow and, thus can be more easily processed in conventional, existing equipment. It must be pointed out also that these materials can be produced at an appreciable reduction in cost based on the total formulation. The cost of the SAIB, being less than that of the cellulose acetate which it replaces, reduces the raw materials expense somewhat.

The harder flows of cellulose acetate find wide spread use in such applications as buttons and decorative moldings, and the softer materials can find applications in other fields. One such application having practical possibilities is that of vacuum-forming. Limited test results indicate that the use of SAIB in a dimethyl phthalate system aids in the ease of deep-drawing and in the reduction of blush.

Improved Classification of Vinyl Resins

Robert Braddicks, Jr.
and Thomas Van Deren
Kentile, Inc.

A practical method for determining processing behavior of poly(vinyl chloride), poly(vinyl acetate) and poly(vinyl chloride-acetate) copolymers

Solution viscosity, specific gravity, bulk density, per cent volatiles and particle size generally comprise the complete product specifications currently offered by domestic resin manufacturers. As a further service typical physical property data representing standard resin-plasticizer-stabilizer recipes are frequently provided. Such data may include tensile strength, 100% modulus, ultimate elongation and Shore hardness for these compounds. Analysis of this information is intended to provide a reasonable guide to the converter for intelligent selection of resins satisfying his requirements. Actually, proper selection of resins remains a serious problem for the processor. Factors contributing to his difficulties are numerous and warrant detailed discussion.

Solution viscosities, as currently provided, are of greater value to the supplier than the user. The polymer manufacturer utilizes these viscosities as a convenient means of quality control. Specifications of limits for specific or intrinsic viscosities assist in assuring that present production adequately matches standards for average molecular weights. However, as *Table I* illustrates, the fabricator is less fortunate than his supplier due to the extreme lack of consistency in presentation of data among resin producers. Inspection of *Table I* shows that viscosity units provided differ widely. Some manufacturers prefer relative viscosities. Others prefer specific, intrinsic or inherent viscosities. Solvents are variable and include, for example, methyl isobutyl ketone, cyclohexanone and nitrobenzene. Viscosities are reported at 20°C, 25°C and 30°C.

As a result of these divergencies it is extremely difficult for the plastic converter to select resin equivalents from the broad offerings presently available. Superimposed upon these difficulties are the uncertainties associated with a change in polymer type, i.e. homopolymer vs. copolymer. Finally, it requires considerable ingenuity and experience to extrapolate from the behavior of a polymer in solution to that behavior expected at high temperatures during processing. Since the processor thinks in terms of "softness" of resin or ease of processing it is certainly desirable that a practical method be furnished for rating this quality.

As early as 1946 it was shown by Dienes and Klemm (4) that molten viscosities of vinyl polymers could be reliably determined. They presented data for plasticized as well as unplasticized vinyl chloride-acetate copolymers. P. Schmidt in 1950 (6) noted a significant relationship between required deformation power and molecular weights of polyvinylchloride resins. The C. W. Brabender Co. (7) presents data illustrating a linear relationship of deformation power determined for plasticized poly(vinyl chloride) resins vs. "K"

Table 1. Lack of Consistency in Reporting Data is Problem for Processors

Manufacturer		Type Viscosity	Solvent	Temperature	Concentration
#1	(a)	Specific	Nitrobenzene	20°C.	0.2 gm/100 ml
	(b)	Specific	MIBK	20°C.	1 gm/100 ml
2		Relative	Cyclohexanone	25°C.	1 gm/100 ml
3		Intrinsic	Cyclohexanone	25°C.	0.3 gm/100 ml
4		Relative	Cyclohexanone	25°C.	1 gm/100 ml
5		Relative	Cyclohexanone	25°C.	1 gm/100 ml
6		Inherent	Cyclohexanone	30°C.	0.2 gm/100 ml

Table 2. Poly(vinyl chloride) Resins—Molten Viscosity Compared with Solution Viscosity

Resin	Solution Viscosity Relative	Molten Resin Viscosity: Mooney 300°F.	Brabender 304°F. 30 RPM	Brabender 304°F. 60 RPM	Modified Carver Plasto-meter 374°F.
Resin #1	1.82	86	790	790	2125
#2	1.99	100	1250	1100	1725
#3	2.18	122	1500	1360	1395
#4	2.37	127	1620	1460	1240
#5	2.52	148	1760	1580	1140

Explanatory Notes:
(1) Column 2—Relative viscosities for 1% solution, cyclohexanone, 25°C.
(2) Column 3—Mooney viscosities for stabilized, unplasticized premilled stocks.
(3) Column 4—Brabender plasticities for stabilized, DOP plasticized premilled stocks. 50 PHR DOP.
(4) Column 5—Carver press modified for controlled temperatures, pressures and flow time. Raw resin, not plasticized, not stabilized. 30 sec. dwell.

values of these polymers. Data determined during this study for plasticized and unplasticized homopolymers as well as copolymers confirm these findings for commercial resins currently available. It will be shown that several commercially available instruments are suitable for determining molten flow data of vinyl polymers. Since this data is relatively simple to obtain, it is suggested that resin manufacturers give serious consideration to the inclusion of high temperature flow data in their product specifications. It is further recommended that this data be provided in terms of an agreed upon standard procedure. *It is believed that acceptance and application of these recommendations by the industry will provide the plastic converter with an improved practical means of classifying polymers for his own end use.*

Theoretical Considerations—Factors Affecting Solution Viscosities

Solvents. Any of the viscosities listed in *Table II* are influenced by the solvent since it determines the general form of the molecule in solution. For a given polymer molecule the mean molecular extension in solution varies with the solvent. High intrinsic viscosities are favored by good solvents and low values by poor solvents, other conditions being equal. As Huggins has postulated (1) not only the magnitude but the molecular weight dependence of the intrinsic viscosity will vary from solvent to solvent. Doty and Mischuck (5) through osmotic measurements noted more than a twofold increase in molecular weight of a purified vinyl polymer fraction when investigating solvent effects. Cyclohexanone representing a good solvent gave a value of approximately 99,000 M.W. while the poor solvating dioxane showed a value of approximately 210,000 M.W.

Type Viscosity. Insofar as securing maximum information from solution viscosities, intrinsic viscosities are preferred. Relative viscosity

$$(1)\ \eta^r = \frac{\text{Solution viscosity}}{\text{Solvent viscosity}} = \frac{\eta s}{\eta o}$$

is a one point determination and therefore subject to greater chance of error. Specific viscosity ($\eta r - 1$) as shown by Einstein is significant when applied to suspensions of rigid spheres but is of limited application to flexible long chain polymers. Extension of Staudinger's original presentation relating specific viscosity to molecular weight within a given species of high polymer led to the introduction and use of intrinsic viscosity.

$$(2)\ [\eta^r] = (\eta sp/c)c \rightarrow o$$

where C is concentration in gms/ml. This quantity has been theoretically and experimentally related to molecular weights of high polymers and, therefore, should be adopted as the basic unit for this purpose. In addition it automatically eliminates the confusion caused by inconsistent concentrations now in use. As indicated by equation (2) extrapolation to zero concentration is required.

Temperature. Viscosity of liquids normally decrease rapidly with increasing temperature such that the logarithm of viscosity is proportional to the reciprocal of the absolute temperature over a reasonably wide range. Intrinsic viscosities do not decrease rapidly with increasing temperatures but are only slightly temperature dependent. Normally intrinsic viscosities for good solvents decrease slowly with increasing temperatures while poor solvents show an increase. (2). Standardization of temperature should be adopted for optimum usefulness of data to the fabricator.

Concentration. Since indirectly the method of solution viscosity attempts to measure the increment of solvent viscosity caused by the dissolved polymer and relating this increment to molecular weight, standardization of concentration is a prerequisite. This is especially true if relative viscosities continue to be provided. As previously mentioned, concentration difficulties are greatly minimized if intrinsic rather than relative viscosities are furnished. Acceptance of this practice will definitely assist in the interpretation of data characterizing equivalent products from different manufacturers.

Polymer Type. Basically, the use of solution viscosities for rating average molecular weights of polymers must be confined to similar chemical polymer types. Vinyl chloride-acetate copolymer solution viscosities, for example, cannot be compared to solution viscosities of poly(vinyl chloride) polymers. Equation 3 represents a modified form of the Staudinger equation believed to be generally applicable

$$\eta_{\,sp/c \rightarrow o} = KM^a$$

to high polymers. Both "K" and "a" are constants for any given polymer solvent system. "M" is the molecular weight, and for an "a" value of 1 the original Staudinger equation is obtained. Hence, changing either polymer type or solvent type requires that new constants "K" and "a" be derived before significant comparisons are possible. Derivation of the constants "K" and "a" of equation (3) requires a calibration by an independent absolute method such as osmotic or light scattering measurements. Depending upon the technique used for calibration different types of molecular weights are provided which must be considered before applying to the viscosity data. Since viscosity average and weight average molecular weights are closely related light scattering techniques giving weight average molecular weights are preferred for calibrating the constants "K" and "a". For poly(vinyl chloride), the unusual behavior in polar and non-polar solvents reported in the literature leads to inconsistent results precluding the derivation of reliable values for "K" and "a". S. N. Chinai (8) has presented a means of estimating molecular weights of polymers based upon viscosity data alone. This method is based upon rigid statistical analysis of published data for many polymers. It presents evidence supporting a possible relationship between

Table 3. Vinyl Chloride—Acetate Copolymers—Molten Viscosity and Solution Viscosity Compared

Resin	Solution Viscosity Intrinsic	Solution Viscosity Relative	Molten Viscosity Mooney—300°F.
#6	0.24	—	0.6
#7	0.53	1.455	5
#8	0.79	1.70	42
#9	1.05	1.88	92
#10	1.15	1.995	160

Explanatory Notes:
(1) Intrinsic viscosities, 20°C.
(2) Relative viscosities, 20°C., 1% nitrobenzene

molecular weight and shape and the slope of the plot $\eta_{sp/c} - C$. In a private communication with the writer he has noted that data for poly(vinyl chloride) and its copolymers were not used in this analysis due to unexplained inconsistencies of data. Mead and Fuoss (9) have reported values for poly(vinyl chloride) in cyclohexanone @ 25°C. where $K = 7 \times 10^{-5}$ and $a = 1$, for equation (3). Using Chinai's method "K" and "a" were computed giving values of 5.1×10^{-4} and 0.41 respectively. Employing these two sets of constants Mead and Fuoss values yield a calculated molecular weight of 14,700 while Chinai's values would give 370,000 molecular weight for the same polymer. In addition to these limitations uncertainties exist regarding high and low temperature performance of polymers, due to changing polymer types as a result of possible internal plasticization caused by certain comonomers. Inclusion of high temperature flow data in product specifications by resin manufacturers as suggested previously is a possible means of minimizing many of the difficulties inherent in the present method of characterizing vinyl polymers.

High Temperature Flow Data

To equip the plastic fabricator with practical supplementary information for more accurately classifying vinyl polymers, the usefulness of molten flow data for these materials was examined. These data were then compared to solution viscosities for these resins. *Tables 2 and 3* summarize the results obtained. Inspection of these Tables show the following:

A. Within a given polymer type, molten flow data and solution viscosities show good agreement.

B. Changing polymer type results in misleading solution viscosities. Homopolymers #3 through #5 exhibit relative viscosities in excess of copolymer #10 yet all have Mooney viscosities below that of 160 found for the #10 resin.

C. High temperature flow data predicts approximately equal processing properties for resins #5 and #10. Actual plant experience confirms this analysis. Yet relative viscosity for #5 resin is reported as 2.52 while #10 has a relative viscosity of 1.99.

Conclusions

These results illustrate the value of molten flow data as supplementary information for the vinyl chloride plastic processor. Extension of solution viscosities to processing behavior is not necessary. Actual response of these materials to deforming forces at processing temperatures is readily available. Ease of processing or "softness of resin" is conveniently ascertained without the complications of variable solvents, concentration effects or changing polymer type. Any of three commercially available instruments are suitable for this purpose. The Brabender Plastograph, the Tinius Olsen Parallel Plate Plastometer or the Mooney Viscometer are capable of furnishing useful flow data. Modification of the Carver Laboratory press as a plastometer has even proven practical. Acceptance of any of these instruments as standard throughout the industry would be an advance towards more fully classifying commercial vinyl polymers and copolymers. The Parallel Plate Plastometer offers the advantage of furnishing flow data in terms of the fundamental "poise" unit (4). On the other hand, the Brabender and Mooney Plastometers offer data obtained under dynamic rather than static test conditions. This dynamic data for viscoelastic materials can provide an advantage of more closely simulating behavior typical of that expected during processing. In addition to classifying stabilized-unplasticized polymers the Parallel Plate Plastometer and Mooney Viscometer are both of value in determining flow data for plasticized stocks. Both plasticizers as well as resins may be compared for equivalencies. Finally, instruments like the Brabender and Mooney are useful in comparing heat stabilities of resin equivalents very close to actual processing conditions. The onset of degradation is detected by an abrupt rise in the power-time curve.

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The Effect of Orientation on the Physical Properties of Injection Moldings

This article gives a method for determining birefringence of molding resins which can be useful for molding control and rapid and non-destructive estimate of properties at various points of the molding

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Various workers have shown that the mechanical properties of plastic parts are anisotropic as influenced by molecular alignment or orientation induced during fabrication. The first half of this article (1) discusses the effect of fabricating (molding) conditions on orientation. The second part of the article considers the effect of orientation on the mechanical properties of moldings.

Similar studies have been made previously on polystyrene film by Bailey (2) and Nielsen & Buchdahl (13), on extruded rods by Cheatham and Dietz (10), and on monofilament by Cleeresman & Karam (11). The mechanical anisotropy of polystyrene injection moldings has been investigated by Högberg (3, 4) who compared the impact strength and density of the surface layer to the interior portion of the molding. Adams, Jackson, and McCarthy (7) showed the variation of impact strength with direction as compared to compression molded specimens. Lee, Horsley, and Wright (5, 6) using a specially designed die to insure uniformity of flow across the die cavity, compared parallel and transverse impact and flexural strengths of a series of specimens cut from various locations of the same molding. Their attempts to correlate mechancial properties to specimen orientation were unsuccessful.

The work presented here was designed to injection mold test specimens over a wide latitude of molding conditions chosen to give a maximum range in the degree of frozen-in orientation and to analyze mechanical properties of the moldings both parallel and transverse to the direction of flow. Correlations between specimen orientation as measured by optical birefringence at the point of specimen fracture and the measured physical property parameters were made and meaningful relationships between mechanical properties and birefringence were found; these results were compared with theory to provide the basis for empirical expressions for practical use in the areas of molding control, non-destructive parts testing, specification testing, etc.

Specimen Preparation

The consideration of anisotropic effects due to orientation precludes the use of "standard" test specimens which are so designed that specimen selection is made only in the direction parallel to the flow of the polymer. An experimental die was designed to produce a sample exhibiting a uniform flow pattern. A further consideration in this design was to allow sufficient dimensional latitude to enable the selection of test specimens to be made both parallel and perpendicular to the direction of flow. The die cavity was trapezoidal with the parallel sides five and seven inches, the height three inches and the non-parallel sides of equal length. The gate was fan shaped and located at the center of the seven inch side. Two dies were constructed, one to mold a sample 0.100 inch thick and the second a sample 0.020 inch thick. Samples were molded on a commercial three ounce injection press. A wide variety of molding conditions were used as shown in *Table 1*.

The variation in degree of orientation within each molding necessitated the utilization of non-standard tensile specimens to ensure fracture at the same location in specimens cut in both parallel and transverse locations. The specimen geome-

Table 1. Molding Conditions of Polystyrene Sampler Used for Studying Effect of Fabrication on Molecular Orientation

Run No.	Material	Thickness (ins.)	Cylinder T_c (°F)	Die T_D (°F)	Pressure P_r (psi)	Cycle* (secs.)	R (Orders)	Birefringence Values $\Delta_n \times 10^4$
1	Polystyrene	0.100	300	80	900	15/15		
2	Polystyrene	0.100	325	80	900	15/15	23 red	51.8
3	Polystyrene	0.100	350	80	900	15/15	11 red	24.5
4	Polystyrene	0.100	450	80	900	15/15	5 gr.	11.4
5	Polystyrene	0.100	550	80	900	15/15	13 gr.	29.7
6	Polystyrene	0.100	400	80	600	15/15	6 red	13.0
7	Polystyrene	0.100	400	120	600	15/15	6 yel.	12.1
8	Polystyrene	0.100	400	180	600	15/30	4 gr.	9.1
9	Polystyrene	0.100	400	80	600	30/15/5	5 gr.	11.4
10	Polystyrene	0.100	400	80	600	20/15/5	5 gr.	11.4
11	Polystyrene	0.100	400	80	600	10/15/25	5 red-gr.	11.2
12	Polystyrene	0.100	400	80	600	7/15/28	5 gr.	11.4
13	Polystyrene	0.100	400	80	600	5/15/30	5 gr.	11.4
14	Polystyrene	0.100	400	80	600	4/15/31	4 red-gr.	8.9
15	Polystyrene	0.100	400	80	600	3/15/32	3 gr.	6.9
16	Polystyrene	0.100	550	180	290	15/30	1 yel.-red	1.1
17	Polystyrene	0.100	550	180	230	15/30	1 gray	0.2
18	Polystyrene	0.100	550	180	230	20/30	1 yel.-red	1.1
19	Polystyrene	0.100	550	180	230	30/30	2 red-gr.	4.3
20	Polystyrene	0.100	550	180	300	25/30	1 red	3.9
21	Polystyrene	0.100	330	80	900	15/15	23 gr.	52.7
22	Polystyrene	0.100	340	80	900	15/15	19 yel.	41.4
23	Polystyrene	0.100	350	80	900	15/15	12 yel.	25.4
24	Polystyrene	0.100	375	80	900	15/15	8 yel.	16.3
25	Polystyrene	0.100	400	80	900	15/15	6 gr.	13.7
26	SAN	0.100	400	80	1000	15/15	17 red	38.1
27	SAN	0.100	450	80	1000	15/15	8 gr.	17.6
28	SAN	0.100	500	80	800	15/15	5 yel.	9.8
29	SAN	0.100	500	80	600	15/15	5 gr.	11.4
30	Polystyrene	0.020	550	180	700	5/30	3 gr.	34.3
31	Polystyrene	0.020	550	180	700	5/30	2 gr.	22.9
32	Polystyrene	0.020	550	120	700	5/30	3 red	30.9
33	Polystyrene	0.020	600	120	800	10/20	3 yel.-red	28.6
34	Polystyrene	0.020	600	80	700	10/20	2 red	19.4
35	Polystyrene	0.020	600	80	700	6/20	1 red	8.0
36	Polystyrene	0.020	600	80	550	10/20	2 yel.	14.8
37	Polystyrene	0.020	600	80	1000	10/20	5 red	53.7

* ram-forward and die-closed time.

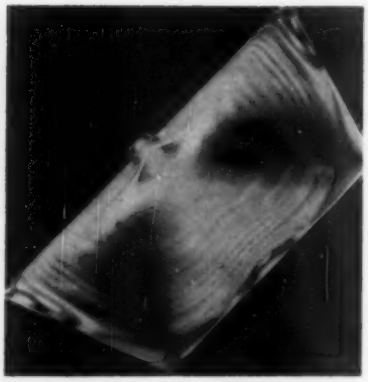

Figure 1. Photograph shows placement of specimens on the molding both parallel and transverse to the direction of flow

try chosen to meet this requirement was a continuous radius dumbell specimen of the type utilized in tensile impact studies (9). *Figure 1* shows the placement of specimens on the molding both parallel and transverse to the direction of flow. Specimens were prepared by sawing one inch wide strips three inches long and milling the arced portion either side of the center using a two and one half inch diameter end mill. The specimens were milled to leave a one-half inch width at the center of the necked portion. *Figure 2* shows tensile specimens prepared from samples of varying degrees of orientation. Impact specimens also were cut from the moldings both parallel and transverse to the direction of flow in essentially the same manner as the tensile specimens. A stress riser (standard 0.010" radius notch) was milled to produce failure in the same location in both parallel and transverse specimens. To obtain birefringence profiles of test specimens at the point of fracture, a 0.010 mil wide strip was cut from the molding parallel to the direction of flow.

Measurements and Results

Specimen birefringence was measured with a polariscope using the techniques described by Ballman and Toor (1). These values, shown in *Table 1*, are total birefringence values which in effect integrate the varying degrees of orientation present through the cross section of the specimen.

Tensile tests were run on specimens of each molding condition, cut both parallel and transverse to the direction of flow. Tests were run on a standard tensile tester at .2 inches/min. crosshead travel rate. Specimen effective gage length was calculated to be 1.189 inches (9). Specimens were gripped so that the leading edge of the grip extended to the point where the arc radius intercepts the straight portion of the specimen. The specimens failed at the minimum cross section as anticipated and strength results were calculated on this basis.

Figure 3 shows broken specimens (the outer bars show impact failures and the inner bars tensile failures). It is interesting to note that degree of specimen orientation as indicated by the birefringence is not visibly changed by the deformation resulting from the tensile test. The specimens cut in the direction parallel to flow crazed just prior to failure. This occurs only in the center of the specimen which demonstrates the variation in critical elongation between the highly oriented "skins" and the center or "core" of the specimen which has a much lower degree of orientation.

Further evidence is presented in *Figure 4* where cross sections of broken specimens are shown; from left to right these specimens are impact and tensile specimens cut parallel to flow and tensile and impact cut transverse to flow with rough laminar fractures apparent in parallel specimens and smoother fractures in the case of transverse specimens.

The relationship between tensile stress at failure and birefringence at the failure point is shown in *Figure 5*. This plot represents the test results obtained on the 0.100 inch thick specimens of polystyrene molded over the wide range of conditions indicated in *Table 1*. In spite of the wide variation in the conditions of sample preparation, there is a good correlation between tensile strength measured on specimens taken parallel to the direction of orientation and birefringence. The curve is similar in general shape to the

Figure 2. Photograph shows tensile specimens prepared from samples of varying degrees of orientation

one predicted by the Hsiao Theory (8) and the data obtained on stretched films by Bailey (2) but indicates a greater strength dependence on orientation. Correlation of birefringence

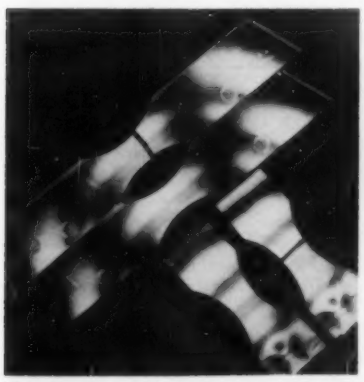

Figure 3. Broken test specimens

Table 2. Results of Tensile Strength Tests

Run	Tensile Stress at fail (psi) ||	Tensile Stress at fail (psi) ⊥	% Elongation ||	% Elongation ⊥	Modulus x 10^5 (psi) ||	Modulus x 10^5 (psi) ⊥	Izod Impact ft. lbs./in notch ||	Izod Impact ft. lbs./in notch ⊥
1								
2	10,170	4550	4.4	2.5	2.43	1.96	1.58	.18
3	7,650	3370	4.8	1.8	1.76	2.05	1.19	.18
4	6,190	4540	4.5	2.6	1.59	1.73	.36	.15
5	6,380	4350	3.9	2.7	1.80	1.71	.53	.19
6	7,380	4190	4.2	1.9	2.52	3.18	.56	.20
7	7,110	4270	4.3	2.2	1.75	2.03	.48	.19
8	6,320	4110	3.9	2.6	1.66	1.77	.36	.20
9	6,410	4450	4.4	2.2	1.80	2.00		
10	6,300	3970	4.0	1.9	1.72	2.07	.44	.21
11	6,610	4240	4.3	2.2	1.80	2.04	.41	.20
12	6,330	4800	3.9	2.1	1.66	2.10	.35	.19
13	6,750	4010	4.3	2.2	1.76	1.92	.44	.22
14	6,450	4120	2.9	2.0	2.64	2.23	.34	.21
15	5,640	3440	3.4	2.9	1.94	1.45	.32	.17
16	3,470	4210	2.5	2.6	1.78	1.80	.27	.22
17	4,430	3600	2.7	2.4	1.88	1.81	.24	.22
18	3,940	3440	2.4	1.8	1.66	2.00	.24	.22
19	5,340	4240	3.1	2.1	1.72	2.06	.32	.21
20	4,890	4310	3.9	2.0	1.97	1.99	.15	.19
21	8,600	3400	5.2	2.0	2.30	1.83	1.57	.18
22	8,660	3440	5.2	2.1	2.10	1.83	1.54	.23
23	7,640	3710	5.0	1.8	1.65	2.01	1.36	.18
24	7,550	4140	4.2	1.9	2.27	2.79	.65	.21
25	7,220	4870	4.6	2.9	1.71	1.67	.52	.22
26								
27	9,620	9110	4.9	5.1	2.12	1.89	.75	.29
28	11,100	8910	5.4	4.9	2.26	1.96	.42	.29
29	10,730	8720	5.1	3.9	2.06	2.75	.42	.44
*30	7,310	1140	6.1		2.31	2.03		
31	6,200	2690	7.7	1.7	1.71	1.75		
*32	7,590	2630	6.8	1.3	1.61	2.27		
*33	7,140	2540	6.7	1.7	1.80	1.94		
*34	7,150	2800	6.1	1.7	1.86	1.82		
*35	5,340	2770	3.3	1.9	2.22	2.02		
*36	5,860	2890	5.9	1.9	1.75	1.75		
37	8,440	1290	7.0	.7	2.01	1.75		

Notch Data

* = yield phenomenon in tension.

and tensile strength measured on specimens taken transverse to the direction of flow is much poorer but does appear to indicate a slight strength decrease with increase in orientation. The 0.020 inch thick specimens show similar relationships to exist. The limited work done on the SAN material indicated a strength-orientation relationship that was at least different in degree if not in kind from that determined with styrene.

Elongation at failure data are plotted against birefringence in *Figures 6 and 7*. The difference in level of elongation values found in the 0.020" specimens is due primarily to the presence of yielding in these specimens. This yield phenomenon was found only in the 0.020" specimens taken parallel to the direction of flow. Elongation data from the transverse specimens were too badly scattered to permit a correlation with orientation to be made with confidence. A possible explanation for this scatter is given by Alfrey (12).

Young's modulus values were plotted against birefringence values as shown in *Figure 8*. No correlation is evident as there is a general random scatter of values measured in both directions. Reproducibility of specimens molded under one condition was found to be good. *Consequently, the modulus level must be dependent on variables other than orientation. This finding is in contrast with the results on stretched polystyrene film by Nielsen and Buchdahl* (15) *which show modulus to increase with increasing orientation.*

Izod impact strength values were measured in accordance with ASTM D-256. The results are plotted against birefrin-

Figure 4. Cross sections of broken specimens

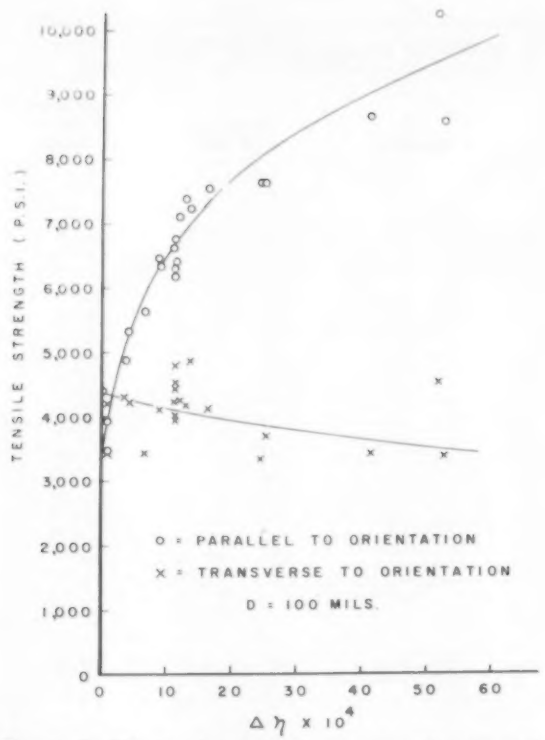

Figure 5. Effect of orientation on tensile strength of polystyrene injection moldings

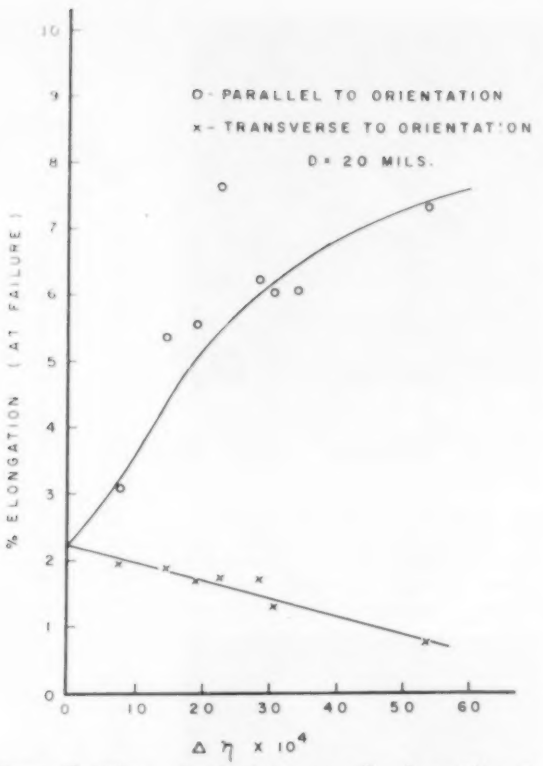

Figure 7. Effect of orientation on % elongation at failure of polystyrene injection moldings

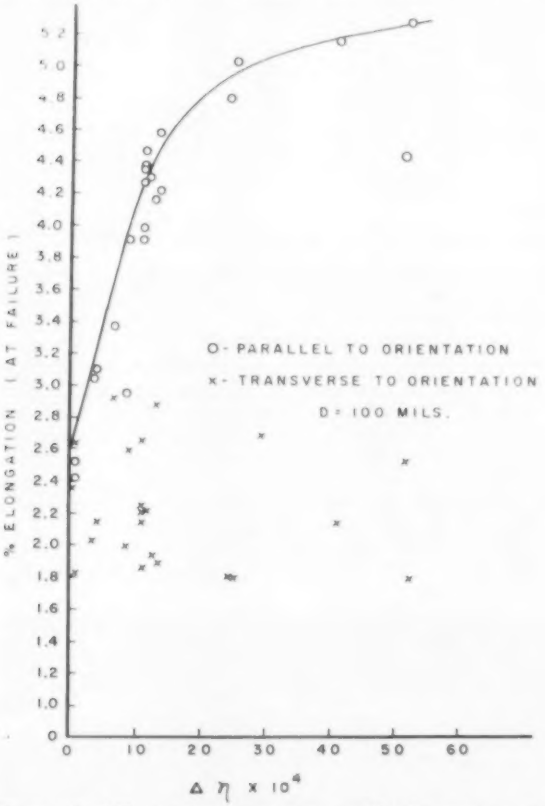

Figure 6. Effect of orientation on % elongation at failure of polystyrene injection moldings

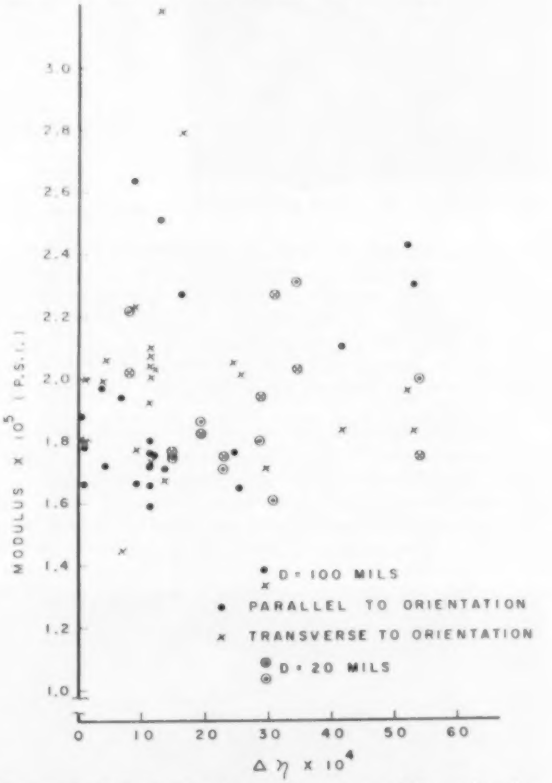

Figure 8. Effect of orientation on modulus of polystyrene injection moldings

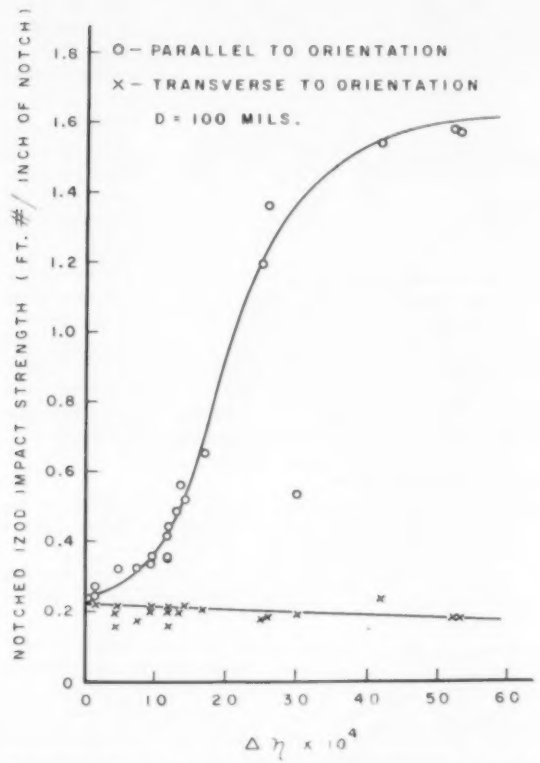

Figure 9. Effect of orientation on impact strength of polystyrene injection moldings

gence in *Figure 9*. As in tensile strength measurements, the impact values increase with increasing birefringence in the case of specimens taken parallel to flow direction. However in this case the dependence on orientation is much greater. Maximum ratios of oriented to unoriented values are approximately 7:1 in parallel impact and approximately 2:1 in the case of parallel tensile strength and percent elongation. In the case of specimens taken transverse to the direction of flow only very small strength differences were observed with large differences in birefringence values.

It has been pointed out that tensile and elongation results of parallel specimens both gave good correlations with specimen birefringence. This indicates that these values can be correlated with each other as is shown in *Figure 10*. Transverse data for a 0.020" thickness specimen also follows the same linear relationship except that it exhibits deviation for the curve established in *Figure 10*. This is due to non linear yield phenomenon (necking) which occurred in testing the thin specimens. These observations are substantiated by plotting the data of Nielsen and Buchdahl (13) on stretched film in the same way, as shown in *Figure 11*.

It is interesting to note that for these samples the relationship between tensile strength and elongation at failure is not only linear but also passes through the origin. It can be represented empirically by $S \times 10^{-3} = 5/3\epsilon$ where S is tensile strength and ϵ is strain.

This apparent Hookean relationship is interesting in that the individual stress-strain curves from which these data are taken i.e. typical stress-strain curves for polystyrene, deviate from Hookean behavior long before the point of failure is reached. The above relationship indicates that this deviation is of the same kind for all the specimens whose data fit on this curve.

A plausible explanation for the above can be based on flaw theory. If it be assumed that a discontinuity or flaw in the polymer network initiates fracture, then the linear relationship between strength and elongation at failure appears reasonable. The flaws in an unoriented specimen are randomly shaped and on the average, the degree of stress concentration is similar regardless of the direction of stress application. On the other hand, the flaws in oriented specimens tend to be elongated in the alignment direction and therefore the degree of stress concentration is higher when stressed in the perpendicular direction. Necessarily, flaw shape and hence stress concentration is proportional to the degree of orientation. *The linearity of the above strength-elongation relationship indicates that the same point stress-concentration may be reached in each specimen at fracture regardless of its orientation and that the measured tensile strength is merely the overall force required to give this stress-concentration as determined by the average flaw shape.*

An interesting factor in the foregoing work is that all birefringence data was obtained by measurements at the point of fracture *through the entire specimen*. This is an integrated value which sums up and averages out any varia-

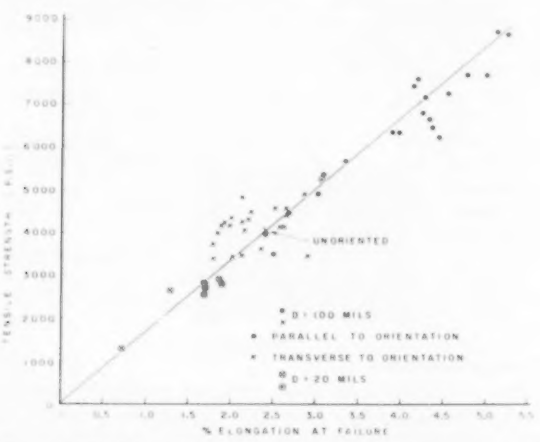

Figure 10. Tensile strength vs. % elongation at failure for polystyrene injection moldings

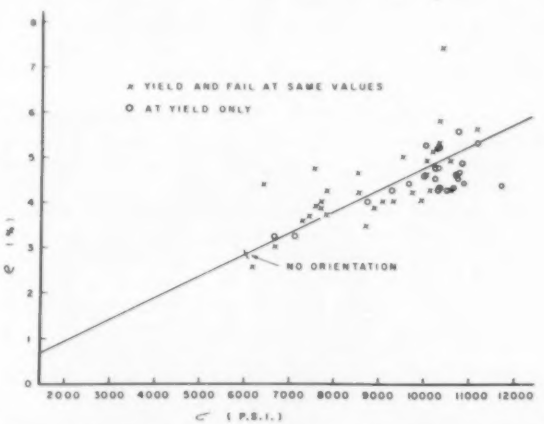

Figure 11. Tensile strength vs. % elongation for stretched films of polystyrene (data of Nielsen and Buchdahl)

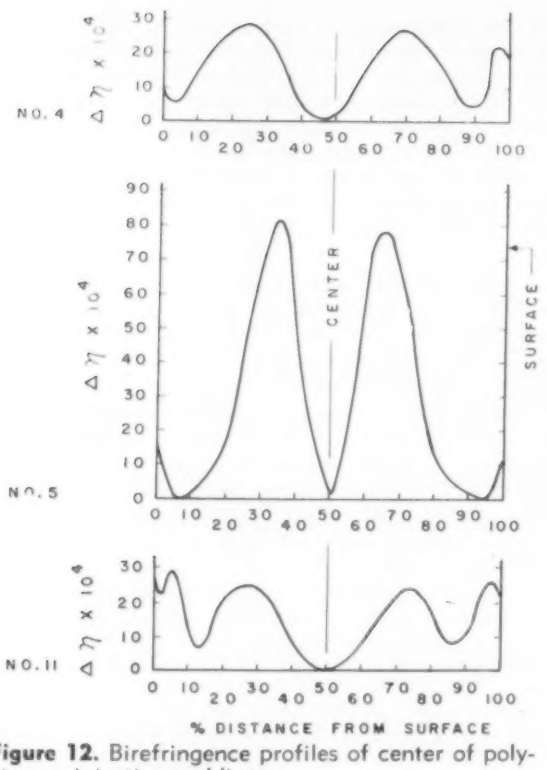

Figure 12. Birefringence profiles of center of polystyrene injection moldings

tions in birefringence through this dimension. That these variations can be considerable is widely known. The effect of these variations on mechanical properties is a subject worthy of consideration.

A previous section described the preparation of 10 mil cross-section sawed from the centerline of each sample. By photographing the central portions of such cross-sections with the aid of a polarizing microscope (18), birefringence profiles can be constructed as shown in *Figure 12*. These profiles demonstrate the variation in orientation through the cross section at the point of fracture for samples Nos. 4, 5 and 11. The birefringence peaks are the highly oriented layers sometimes referred to as "skins". Between these peaks is the unoriented central region of the molding. It will be noted that the two halves of the profiles are not exact mirror images. This is probably due to slight differences in temperature between the die surfaces resulting in different plastic cooling rates leading in turn to slight differences in the amount of stress relaxation.

If the profiles were arbitrarily divided up into many small increments, it was found that the strength of each increment can be added up to give close agreement with integrated specimen strengths as shown on *Figures 5 and 6*. This means that the birefringence-strength correlations obtained on entire moldings correspond closely to the correlation which could be obtained on specimens of uniform birefringence throughout. Furthermore, it means that moldings behave as if they were a series of parallel, independent layers each contributing its own strength (as determined by its orientation) to that of the whole. Lastly, it means that in predicting mechanical properties such as tensile strength, integrated birefringence values should be sufficient.

As a practical aid to using the birefringence-mechanical properties relationships shown above, the following empirical relationships were found to fit the data for one commercially available polystyrene:

Tensile Strength (parallel to orientation)

$$S_u = \frac{11B^2 + 11B\,\Delta\eta}{11B^2 + 3B\,\Delta\eta}\,S_o$$

where B = 15, $\Delta\eta$ is birefringence, and S_o is unoriented tensile strength.

%Elongation @ Failure (parallel to orientation)

$$E_u = \frac{11B^2 + 11B\,\Delta\eta}{11B + 3B\,\Delta\eta}\,E_o$$

where B = 15 and E_o is elongation of unoriented specimen

Similar relationships could be worked out for any transparent, amorphous molding powder to fit the requirements of other molding jobs. It is anticipated that such information would be of use for molding control purposes, rapid and non-destructive estimates of properties at various points of the molding and that the concepts set forth in this work may assist in developing and modifying specification test techniques for materials of the nature discussed.

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Acknowledgment

The authors wish to thank members of the Styrene and Evaluation Research Groups of Monsanto Chemical Co. for their generous assistance in preparing and testing the samples utilized in this study. Acknowledgment is also made to Messrs. G. C. Claver and L. Child for photography.

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SOCIETY ACTION

Section Activity Course Survey, New Brochures, Feature SPE Education Progress

C. C. Winding, *Chairman,*
SPE Education Committee,
(Cornell University)

Advances on a broad front in plastics engineering education are being made during 1960 through the activities of SPE Sections and of our Education Committee.

Assisted by our Committee's Section Educational Guide Book mailed to all Sections early in the year, SPE Sections have accelerated their cooperative aid to educational institutions in their local areas. Incidentally, in harmony with similar SPE publications, the former "Guide Book" has been changed to "Manual of Procedures for Section Education Committee Chairmen".

Some examples:

Kansas City Section has organized the first plastics course offered at Kansas City University, and is providing the teachers—SPE members affiliated with the Kansas City Section.

Detroit Section has launched a plastics engineering course in the Highland Park Adult Education Program. The course consists of 10 two-hour lectures and will begin in January, 1961.

Philadelphia Section has cooperated in planning seven evening courses in plastics technology at the Philadelphia Textile Institute.

New York Section's Adult Education Program is operating in high gear. Courses in mold design, compression molding and reinforced plastics are sponsored at the New York Institute of Technology and other courses are sponsored at the Machine and Metal Trade School.

Southern California Section has become sponsor of courses in polymer chemistry at the University of Southern California.

Ontario Section has expanded and improved the comprehensive course in plastics technology that it initiated in 1958 at the University of Toronto. A complete description of this successful course will be published in the November issue of the SPE Journal.

Newark Section—The courses in plastics technology at the Newark College of Engineering sponsored by this Section have expanded to four—process properties, extrusion, product design and auxiliary tooling. The Section also supplies instructors and helps to place graduates.

(Continued on page 1170)

EXTRA DIVIDENDS OF SPE MEMBERSHIP

S. M. Crawford, *Chairman Membership Committee*

Recently I have received a number of letters from SPE members advising me of their resignation from our Society. In many cases, they advise me that their reason is because they cannot regularly attend Section meetings.

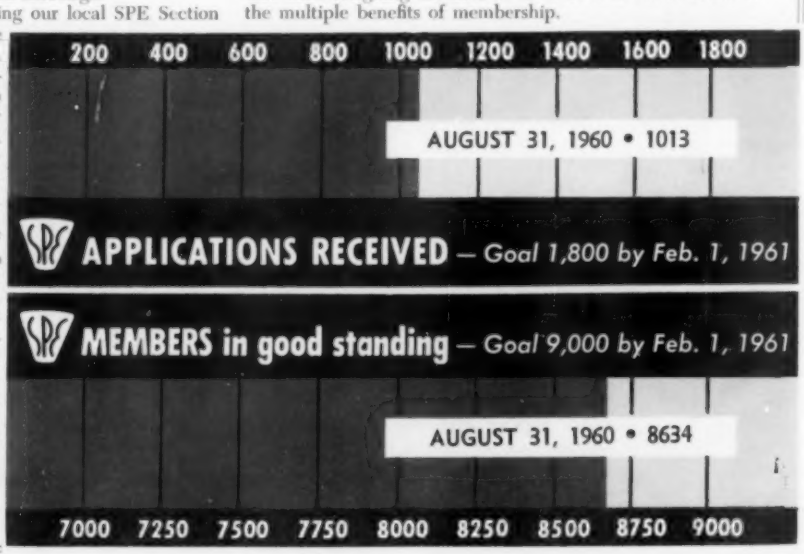
We all realize the value of attending our local SPE Section meetings because they are the backbone of our organization. However, there are many important benefits of SPE Membership in addition to those obtained by participation in Section meetings. I am quoting below a recent letter Lew Bernhard, who handles membership in our Executive Office, sent to a resigning SPE member.

"We have received your letter of August 17, originally directed to SPE Membership Chairman, Sherman M. Crawford. Without wishing to impose upon you, we would like to ask you to reconsider your intention of resigning your affiliation with this Society.

Many of our members find regular attendance at SPE Section Meetings difficult, generally because of lack of time or because of the distance of the meeting place. Nevertheless, they find SPE Membership most advantageous.

Your association with SPE will keep you abreast of the latest developments in the industry, through the SPE Journal, and Technical Conferences.

I would like to request that each Section arrange to contact each resigning member to be sure that he is aware of the multiple benefits of membership.



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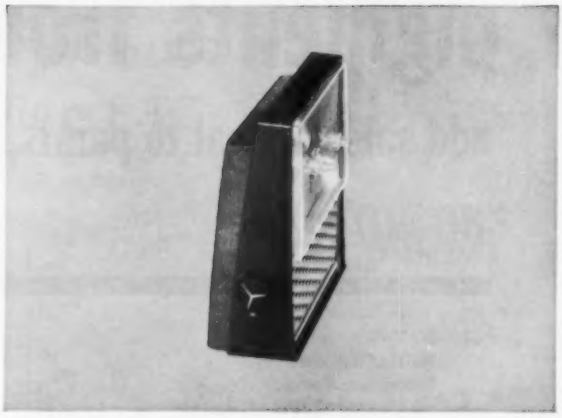

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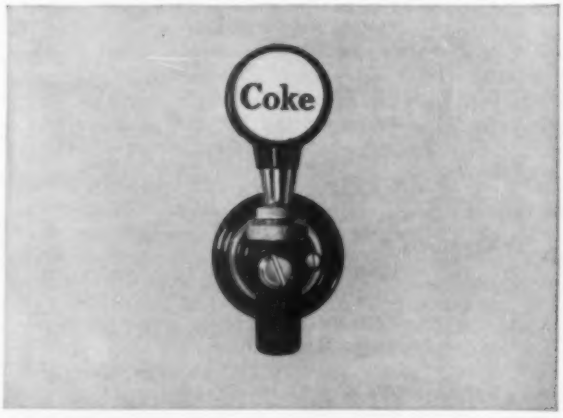

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Education—A Major Goal of the Injection Molding PAG

Roger B. Staub, *Chairman, Injection Molding PAG*
(Union Carbide Plastics Company)

PAG Progress

The general scope of the Injection Molding Professional Activity Group is to develop, coordinate, and disseminate engineering knowledge and technical information on injection molding. Within this scope, the following projects are being actively pursued:

Injection Molding Workshops

One of the most effective means of bringing the industry up-to-date on new developments in processing fundamentals and production techniques is the presentation of periodic workshops. This was effectively demonstrated by the success of the Extrusion Workshops organized by the Extrusion PAG. Therefore, the Injection Molding PAG set the organization of Injection Molding Workshops to be held in 1961 as one of its 1960 goals.

A proposed program was determined, and "feelers" were sent to all SPE Sections requesting their comments and interest in such a workshop. The Pioneer Valley Section expressed considerable interest in the program and agreed to sponsor the workshop in conjunction with the Injection Molding PAG.

The first workshop will be a two-day session to be held at Holy Cross College, Worcester, Massachusetts, in the Spring, 1961. The objective of the workshop is to present information of practical usefulness each day in the injection molding plant. Accordingly, the lectures will be aimed particularly at molding supervisors and shop foremen.

The first day of the workshop will be devoted to the fundamentals of injection molding and the applications of these fundamentals to molding shop practice. The second day will deal with specific phases of injection molding production such as trouble-shooting hydraulic and electrical difficulties, plant layout and materials handling, and special techniques in maintaining production. A panel discussion, with all the speakers present will be held as the last session.

A Workshop Committee consisting of the Steering Committee of the Injection Molding PAG and Messrs. Richard Bishop and John Meyers of the Pioneer Valley Section are preparing the workshop. A general announcement of the speakers, their topics, and other arrangements will be forthcoming at the 1961 Annual Technical Conference (ANTEC). The Pioneer Valley Section and the Injection Molding PAG are very enthusiastic over the workshop program, and are confident the workshop will be informative and useful to the injection molding industry.

Panel Discussion for 1961 ANTEC

At the Injection Molding PAG meeting at the 1960 ANTEC in Chicago, the membership requested that a panel discussion concerning some phase of injection molding be held at the 1961 ANTEC. In accordance with this request, the PAG Executive Committee has organized a forum, "Preplasticizing in Injection Molding"—a subject of considerable interest to all injection molders.

The discussion is organized around three speakers; a molding supervisor with considerable production experience in the use of preplasticizing equipment, a representative from a manufacturer of ram-heating cylinder preplasticizing machines, and a representative from a manufacturer of screw plasticizing machines.

Serving as speakers and panel members for the session will be Mr. William Rackett, Plant Superintendent of Lincoln Molded Plastics Company, Mr. W. G. Kriner, Sales Manager of the Hydraulic Press Manufacturing Company, and Dr. Herbert Frimberger of Ankerwerk Gebr. Goller, Nurnberg, West Germany. These men are well qualified to speak on preplasticizing in injection molding. We urge all those attending the ANTEC who are interested in injection molding to participate in this forum.

Solicitation and Review of ANTEC Papers

An ANTEC Reviewing Committee has been organized under the chairmanship of Mr. Roger Johnston. This committee is working with the 1961 ANTEC Speakers Committee and is reviewing proposed injection molding papers. To solicit papers for the ANTEC, this committee sent out a special letter to selected qualified personnel in the injection molding industry and the IJMPAG membership urging their participation in ANTEC.

It is felt the PAG's should actively work toward the continued improvement of the technical papers presented at the Society's ANTEC. With this in mind, the Injection Molding PAG has initiated a program to select specific topics for research culminating in presentation of papers at ANTEC. Mr. Irvin Rubin, the coordinator of this activity, is currently selecting suitable topics. These topics will cover areas of injection molding where there is a basic need for development of additional engineering information. When the selection of topics is completed, the Injection Molding PAG will contact qualified personnel in the industry urging them to conduct experimental work in areas that would ultimately result in ANTEC papers.

Present Officers (1960)

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J. Roger Johnston, Vice Chairman (Foster-Grant Co.)
Bennett Nathanson, Secretary (Monsanto Chemical Co.)

Steering Committee Members

Neil Keiser, (E. I. du Pont de Nemours and Company)
David Mersey, (Multi-Plastics Corp.)
Irvin Rubin, (Robinson Plastics Corp.)

At present, the working core of the Injection Molding PAG is a small, but active group. We hope our programs will stimulate the interest of other members of the Society to actively participate in our Professional Activity Group.

—— ■ ——

edited by
Frank W. Reynolds, *PAG Administrator*
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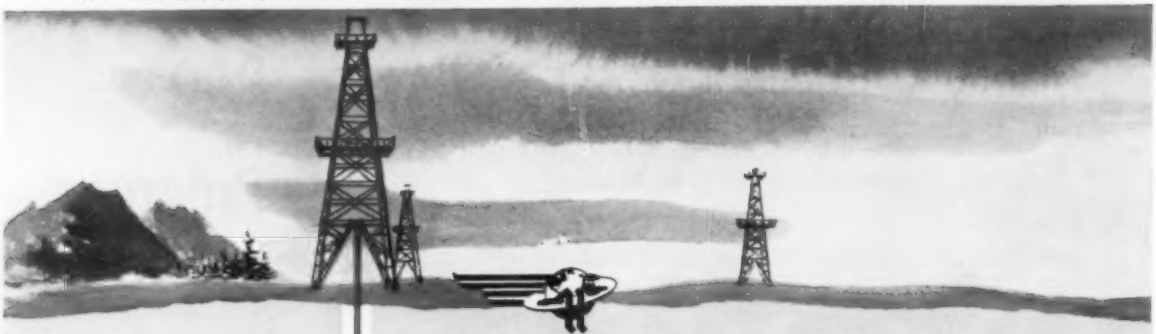

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PLASTICS AROUND THE WORLD

Italy

MATERIE PLASTICHE

JUNE 1960

38th Annual Milan Fair—pp 491-585

Plastics at the 38th Annual Milan Fair—by L. Rizzi—pp 491-518

Plastics and Synthetic Rubbers in the Montecatini Pavilion—by S. Croce—pp 519-536

Plastics in Other Sections of the Fair—by E. Ferraris—pp 537-555

Machines for the Fabrication of Plastics at the 38th Milan Fair—by A. Osella—pp 561-585

This year 34 nations exhibited to 94,000 visitors from 115 countries. The exhibits stressed the wide capabilities of the exhibitors in range of products and equipment rather than new developments in the field. Each article is well illustrated and gives names of materials, specifications and manufacturers as required.

JULY 1960

Plastics at the 1960 Interpack—pp 639-662

The International Fair of Packaging and of Machinery for the Packaging Industry was held at Düsseldorf April 20-27. The exhibit area more than doubled over 1959 and the exhibitors increased to 504. A meeting of the Congress of the European Packaging Federation was held at the same time, making this one of the most important plastic events in Europe this year. Exhibits are described, discussed and illustrated.

Prefabricated Dwellings—pp 663-667

Diogene S.A.S. of Turin has designed a plastic unit with modular walls based on a circle which, by changing interior partitions and furnishings, may be suited to individual housing, motels, hotels, restaurants, clubs and so forth. Illustrated.

Considerations in the Construction of a Reoxidation Tower from Rigid PVC—pp 668-671

Rigid sheets chosen for a large structure must be free of stress and must not warp during and after fabrication. Welding can best be accomplished with automatic machines to insure uniformity, and where this is not possible, the very highest quality of hand work is in order. This tower stands freely, having a steel frame surrounding it against which it can lean and which affords walkways and pipe supports for accompanying equipment. The steel supports must be adequately isolated from the corrosive chemicals within and provision must be made for attachment between materials of differing coefficients of expansion. Safety devices must include provision for working temperatures and pressures to be kept within the limits for the material.

Polyethyleneglycol Terephthalate (Part 1)—pp 689-700

Part 1 of a review on this important material: it covers synthesis, description of the polymer, forming fibers, dyeing, identification and uses. 116 References.

AUGUST 1960

Physical and Chemical Properties of Polypropylene Monofilaments—pp 723-730

The principal mechanical, thermal, electrical and chemical properties of monofilaments of isotactic polypropylene are herein presented by text, graph, table and photograph.

Polyethyleneglycol Terephthalate (Part 2)—pp 775-790

Part 2 of a review article. This section covers polymers, fibers, films and applications for this material in its various forms. 142 literature references.

POLIPLASTI

MARCH-APRIL 1960

Plastic Door and Window Frames and Room Dividers—pp 28-31

The author discusses developments in the field and hopes for wider acceptance of plastics products in these applications.

The Use of Colored Polyethylene for Food Packaging—p 41

Although pigments and processing aids in polyethylene become well coated and insulated in the mass, thin packaging films bring the additives closer to the surface. Determination of toxicity must take account of the agent, the amount of it which is capable of migrating to the surface, the migration into the surface of the material being packaged, and the chemical relationship between the two.

Glass Reinforced Plastics in Street, Rail, Air and Sea Transportation—pp 76-80

The industrial use of reinforced plastics continues to increase because of freedom in design, economies in fabrication, and excellent performance in use. Advantages are enumerated; and a list of current applications supplement the photographic illustrations.

Reinforced Plastics at the 38th Milan Fair

Well illustrated article on the products exhibited at the Fair including, boats, tanks, auto parts, electrical accessories, filter press parts, pipes, cement forms, sanitary fixtures and builders' supplies.

France

INDUSTRIE DES PLASTIQUES MODERNES

JULY 1960

Infra-Red Spectrometry by Means of Reflection—(author—J. Henniker)

Infra-Red Spectrometry is a well known method of analysis and identification of plastic poly-

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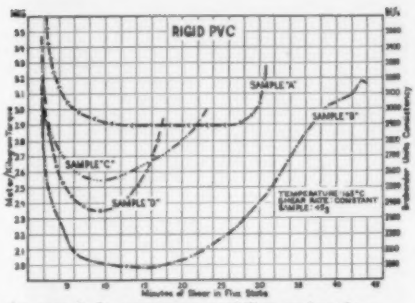
mers. The application of this method was limited to transmission through the specimen to be tested and presented the problem of preparing very thin test samples. The new method described is based on reflection rather than transmission and does not necessitate any preparation but the polishing of a small surface spot on the part to be subjected to the test. The results of tests on several groups of plastic materials are listed.

Preparation of Thermosetting Polyvinyl Resins—S. A. Szewzyk

A number of polyvinyl compounds can be condensed with formol, resulting in a thermosetting polyvinyl resin. The polyvinyl based compounds, suitable for this application and the properties of the resulting thermosetting materials are discussed.

Laminated Polyester Airgenerator Blades—(author—L. Vadot)

From the point of view of weight, mechanical strength, weather resistance etc. glass reinforced polyester laminates offer advantages compared to metal constructions in the field of blades for high power aerogenerators. Various methods of construction of these blades in sizes up to 115 feet are described.



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L'OFFICIEL DES MATIERES PLASTIQUES

JUNE 1960

Phenol Formaldehyde Resins—pp 471-480
Dimensions of the machinery for, and calculations concerning the cooling, grinding, precuring and storing of molding compounds in a small factory are given.

The Shaping of Hollow Objects—pp 488-491
Descriptions and drawings of American and French machines which make plastic bottles analogous to the glass blowing process. (Drawings, references.)

Films and Sheeting—pp 481-487

The European manufacture of cellulose acetate and poly (vinylchloride) films does not differ greatly from the American practice. During the war large amounts of poly(vinylalcohol) were used in Germany for the manufacture of mechanical belting. Such belts have a life of two years when in continual use. As PVA is a thermoplastic resin, the belts could be used at slow speeds only. (57 references.)

Recent Applications of Plastics in Electrical Engineering—pp 501-508

Abstracts of 131 (mainly French) patents.

JULY-AUGUST 1960

Phenol-Formaldehyde Resins—pp 543-555
The calculations for the colorant mixing equipment in a small plant are given. The auxiliary equipment for heating, cooling and materials transfer is fully illustrated.

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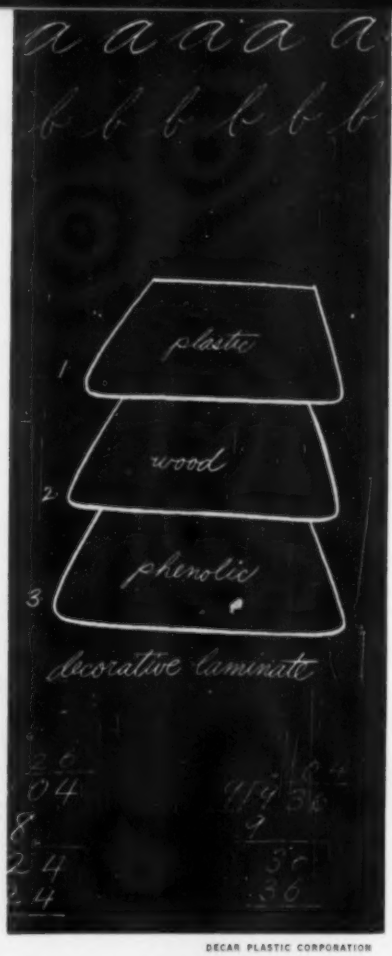

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For more information on Durez materials mentioned, check here:

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- ☐ Phenolic resins—illustrated bulletin describing uses
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KUNSTSTOFF-RUNDSCHAU

MARCH 1960

Soviet Union Plastics Production According to Their Seven Year Plan—p. 140

Production of plastics materials is expected to increase from 4.7 kilograms presently to 16 kilograms per person in 1965. The quotes for production of polyethylene, polyvinyl chloride, polyester and polystyrene are especially high. Total production must increase 700 percent to meet these objectives. By 1961, it is expected to increase 250 percent. Total production in the country is small so that increases seem high when expressed in percentages. In particular, new proposed processes will be introduced. For example, laminating presses will no longer be fed by hand, but mechanically. Production of polyester should progress the most rapidly along modern technological methods, since this material is required for machinery, building construction and other industry branches. If productiivty of the plastics industry is to increase fourfold, modern machinery is required such as for molding glass fiber reinforced plastics, injection molding machines, presses with automatic program controlling devices and automatic equipment for making plastic products such as foil and hollow articles.

Plastics with New Inorganic Elements—pp. 121-125

The synthesis of macromolecular polymers containing inorganic components developed rapidly in 1959. This article is concerned with 1.) inorganic ingredients and additives, 2.) organometallic catalysts and 3.) plastics containing inorganic components.

1. It is commonly known that fillers such as clay, chalk, etc., improve the hardness of plastic resins as well as lower their cost. There are other important branches where these inorganic fillers are important in plastics, such as the improvement of adhesion and protective coating on metal surface. Electrical and thermal conductivity of plastics are also influenced significantly by these organic fillers.

2. The important role of aluminum and titanium (ions) in the synthesis of organic polymers has been shown by Natta and Ziegler in their work with organometallic catalysts.

3. Inorganic elements have been incorporated into well-known polymers for some time. Typical examples are PVC; urea and melamine; polyamides; thiokol; and also fluorinated hydrocarbons, which contain chlorine, nitrogen, sulfur and fluorine, respectively. The elements receiving intense worldwide attention today are, for example, silicon, boron, aluminum, nickel, magnesium, especially in oxygen bonds. Other metals are also being investigated, including tin, germanium, lead and antimony. One of the areas of immediate importance for these polymers containing inorganic constituents is high temperature resistant plastics materials.

KUNSTSTOFFE

JUNE 1960

Heavy-Duty, Light-Weight Constructional Elements Made from Glass Fibre Reinforced Resins—p 318

After discussing the mechanical properties of glass fibre reinforced plastics, a process is described whereby it is possible to control the introduction of the lines of force in highly stressed constructional elements. Rotors for helicopters and spring elements made by this process are discussed.

Specific Heat of Polypropylene—p 335

The mean specific heat and enthalpy of isotactic polypropylene (e.g. Hostalen PPH and PPN), both at 20°C., were determined in a temperature range of 0-300°C. The specific heat was found to be practically independent of the molecular weight.

PLASTE UND KAUTSCHUK

MAY 1960

Cellulose Triacetate for Use as a Raw Material of Varnishes and Plastics. IV—Further Studies on Plasticizers for Cellulose Triacetate—pp 215-219

After a description of operating and testing methods, details are

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given of the efficiency of some groups of substances for use as plasticizers. Substances tested include chlorine diphenyls, chlorine dioxal, chlorale derivatives and some phenol derivatives. The article will be continued.

Polyethylene Laminated Paper—pp 224-227

Fields of application of polyethylene laminated paper and different methods and machines for the manufacture of the lamination are described. The paper concludes with observations on processing by printing, welding and bonding techniques.

DER PLASTVERARBEITER

MAY 1960

Thermoforming of Low Pressure Polyethylene—pp 241-245

Experiments conducted on production type of equipment have shown that it is possible to vacuum form parts from low pressure polyethylene with good dimensional tolerances. The vacuum forming of these parts from low pressure polyethylene is not essentially different from that of high pressure polyethylene except that an exact knowledge of the properties of the materials are essential. Deep drawn articles could be prepared when good temperature control was observed. The paper contains two examples and the calculations dealing with the

DER PLASTVERARBEITER

MARCH 1960

Packaging Materials from Plastics—p 140

Packaging industry progress in Germany is illustrated by the following statistics:

In 1957, packaging materials from plastics were valued at 163 million DM (Deutsche Marks) or 3.20 DM per person; 1958, 205 million DM or 4 DM per person; and in 1959, 240 million DM or 4.6 DM per person. The packaging industry in West Germany was highlighted by an international packaging exposition in April, 1960 in Dusseldorf. It was called INTERPACK and represented by nations throughout the world.

Production, in millions of DM, of plastics packaging products in West Germany for the past three years has been tabulated by major end-use classifications.

Product	1957	1958	1959
Bags, Sacks, pouches	85.0	106.5	120.0
Bottles	5.4	10.1	17.0
Boxes and Tubes	29.1	35.5	41.0
Cases	1.9	2.9	4.0
Drums, Tanks, containers	6.6	8.3	10.0
Covers, Stoppers, screw caps and other closures	30.7	35.5	40.0
Miscellaneous	4.1	5.9	8.0
TOTAL	162.8	204.7	240.0

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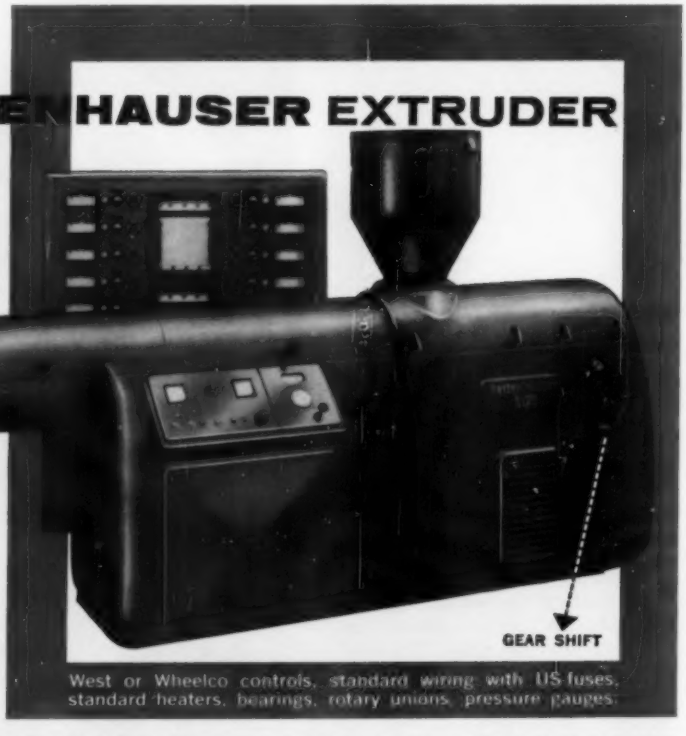

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vacuum requirements. The shrinkage of vacuum formed parts is further discussed in detail.

JUNE 1960

Vacuum Drawing of Polycarbonate Sheets—pp 261-264

The vacuum forming on an experimental basis with a positive and a negative method and later on a production basis have shown that the vacuum forming of polycarbonate sheets is feasible. It was found that the sheets must be stored in a dry condition in order to obtain an acceptable drawing. Sheets which are suspected to be less than oven dry must be predried prior to forming. The sheets should be heated to a minimum of 350°F. and the form should be heated to approximately 240°F. The article is well illustrated and contains experimental data on the operation.

The German Exposition in Hanover as the Mirror of the Free Economy—pp 272-273

The article summarizes the various speeches made at the opening of the exposition and gives a thorough resume on the progress and the new developments of the German plastics industry.

England

BRITISH PLASTICS

JULY 1960

Problems and Trends in Injection Moulding—pp 276-278

This paper opens the July issue of British Plastics, which is completely devoted to injection molding. A number of interesting observations are presented on various subjects such as pre-plasticizing in modified extruders, the economics of multi-stationary machines, that is, machines where the molds are put on a rotating table, and mold design. The possibility of using induction heating to heat selected parts of the mold is given special attention.

Injection Moulding of Acetal Resin—pp 279-281

The acetal resin discussed is the Du Pont product known as Delrin. The same information has been published before in the American trade journals.

Injection Moulding of Polypropylene—pp 282-284

Injection molding of polypropylene is now readily available in the

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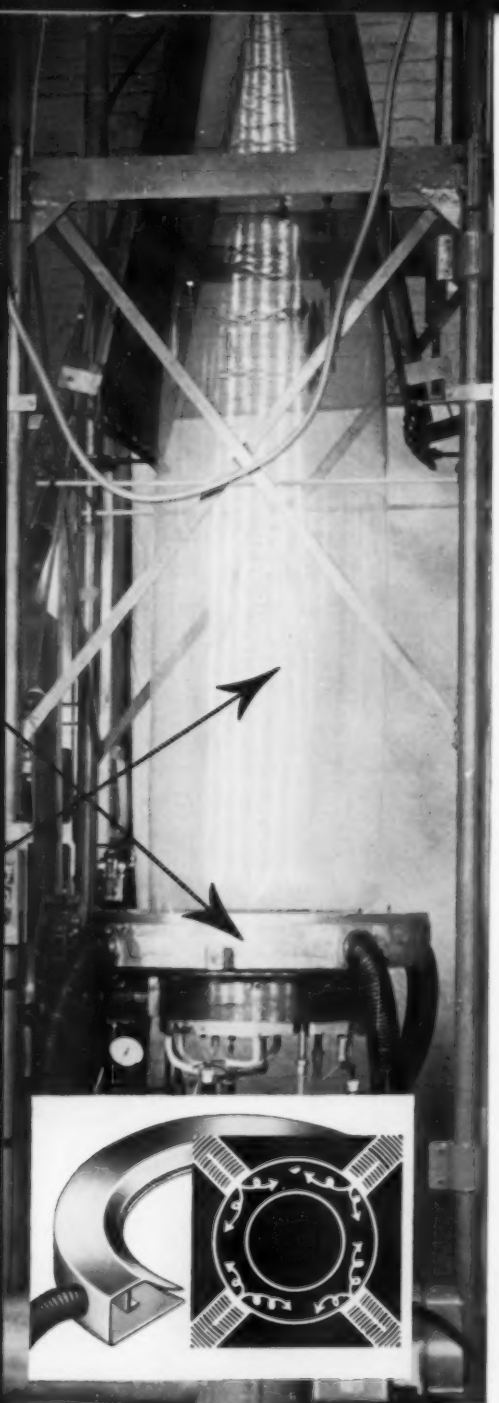

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United Kingdom and this article reports on field experience so far gained. Factors like molding temperatures, molding pressures and rate of injection, holding time, gate size, and mold design precede a section on molding experience. It has been found that polypropylene is susceptible to cavitation faults in thick sections. This is caused by a combination of factors such as high melting point, high density, and high degree of crystallinity occurring when thick sections cool slowly. Polypropylene also has a tendency to form a grain effect, which it shares with high density polyethylene. It is caused by uncoiling and orientation of the molecular chain along the direction of flow. This orientation can cause brittleness, heat distortion, and unequal shrinkage. A high melt temperature in molding is beneficial.

Injection Machines of the World—pp 285-330

This section of the July issue is, we think, extremely interesting in that it presents a very complete and well-prepared presentation of the currently available injection molding machines made in the following countries: Austria, Czechoslovakia, Denmark, France, Germany, Italy, Japan, Sweden, Switzerland, United Kingdom, and United States. It takes an expert to evaluate the special advantages of each construction but at least it gives the reader a good idea of the multiplicity of the designs currently available.

Development of Plastics in U.S.S.R.—pp 335-337

By now it is generally admitted that the Russian technological advancements cannot be taken lightly. This certainly applies to the development of the Russian plastics industry. Under the seven year plan, the output of plastics is expected to increase eight-fold to at least 2 million tons. A large share of the research is being done at the NIIPM (Plastics Research Institute) in Moscow. The review covers very briefly the main work done at the Plastics Research Institute and developments in automation and raw materials. The raw materials available in Russia cover practically the whole field and include: phenolics and aminoplasts, polyolefins, polystyrene, polyvinylchloride, polyvinylacetates, cellulose derivatives, polyamides, polyurethanes, epoxides, silicones, and polyacrylics.

—■—

ABOUT MEMBERS

Mr. Gammel

Walter A. Gammel, Sr. has joined National Connector Corp. of Minneapolis as Director of Marketing. Prior to joining National Connector, Mr. Gammel was General Manager of Automatic Process Control, Inc. He is Chairman of SPE's Plastics in Electrical Insulation PAG and is a member of ACS, SAE, AIM, and ASTM.

Ernest P. Moslo is the author of a new book "Runnerless Molding." Mr. Moslo is a pioneer in making runnerless molding equipment. His new book covers theory, design, applications, and economics of the runnerless method.

John J. Doyle, a member of the Detroit Section, has been named Automotive Technical Coordinator for Rohm & Haas Co. He will be responsible for correlating technical problems on new materials and applications in the automotive field.

Edward J. Cox has joined the sales department of Monsanto Chemical Company's Plastics Division at Springfield, Mass. He is a graduate in chemistry from Tufts University.

Joseph L. Schafer, Newark Section, has joined Radiation Applications Incorporated as research chemist. Mr. Schafer previously was with M. W. Kellogg Co. and Minnesota Mining and Manufacturing Co.

Louis E. Tallman of Dow Chemical Co., Torrance, Calif. was a recent visitor to Australia. Mr. Tallman, who is President of the Southern California Section of SPE, reported that the Australian plastics industry would be four times its present size by 1970.

Henry Clark is now Manager of Engineering and Production Costs Control of Rexall Drug and Chemical Co. He was formerly with the Tupper Co., Rexall subsidiary.

Mr. Ashbaugh

Bernard D. Ashbaugh was recently appointed Manager of Plastics Equipment, Farrel - Birmingham Co., Inc., Watson-Stillman Press Division, Rochester, N.Y. He will direct the sale of the company's line of molding machinery.

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Industrial Control Division

Mr. Scheurer

George J. Scheurer is Manager of the newly created Plastics Division of Chem Products Inc., West Warwick, R.I. Mr. Scheurer, who has had wide experience in plastics, received his degree in chemical engineering from the University of London. He was formerly with the Wm. Brand-Rex Division of American Enka Corp.

Charles W. Hamilton starts duties as Laboratory Director, Plastics Applications Research for Continental Can Co., Chicago. He goes to Continental Can from Battelle Memorial Institute.

Anthony P. Beaudry heads up the sales staff of Reed Plastics Corp. Mr. Beaudry was a founder of the Pioneer Valley Section of SPE and served on its board for four years.

Mr. Herman Reffe heads up all sales for Cordo Molding Products, Inc. He was formerly with the Electro Tech Division of Sun Chemical Co.

Robert F. Lindly has been named the new representative in the Minneapolis, Minn. area for General Electric's line of industrial laminated plastics.
Mr. Milton Freifeld has joined the technical staff of the Central Research Laboratory of General Aniline & Film Corp.

Paul C. Roche has been appointed President and Treasurer of Erie County Plastics Corp., newly formed to injection mold thermoplastics. He was formerly Vice President of Nosco Plastics. **William P. Hayes** is Vice President and General Manager of the new corporation. **Mr. Roche** is a Past President of the Northwestern Pennsylvania Section of SPE.

Orwin G. Maxson has entered into a partnership and formed a new company—Luma Industries Co. Luma will extrude vinyls, polyethylene, polystyrene. Mr. Maxson was with Dow Chemical Co.

Robert L. Schwan joins Schnectady Varnish Co., Inc. as Product Sales Manager. He will direct domestic sales and marketing of the Company's laminating, adhesive, can coating, plywood adhesive, and cork binder resins.

Education Briefs

Quebec Section is sponsoring an extension course, "Plastics Technology" at McGill Univ., Montreal. Course began October 4, and additional information may be obtained direct from the University.
Ontario Section is sponsoring a Plastics Course at the University of Toronto. Course starts October 11, and registration can be by mail or in person at Room 207, 65 St. George Street, Toronto.

Erratum

The name of L. S. Shaw was inadvertently omitted from the Roster of Members, published in the August SPE Journal. Mr. Shaw, now deceased, was a Distinguished Member of the Society.

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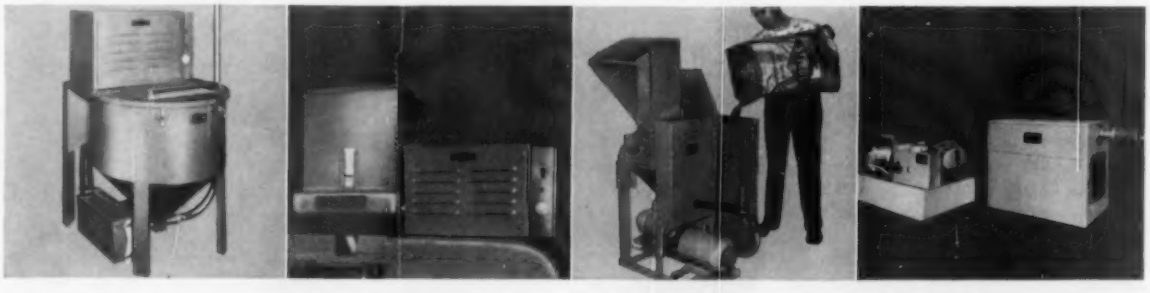

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TECHNICAL MEETINGS CALENDAR

17th ANTEC

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1960 RETECS

October 5—Plastics vs. Corrosion, Golden Gate Section, Mark Hopkins Hotel, San Francisco; Calif. Chairman: J. W. Richardson, c/o Rohm & Haas Co., 600 California St., San Francisco 8, Calif.

November 7—Automation in Injection and Compression Molding, Ontario Section; King Edward Sheraton Hotel, Toronto. Chairman: J. M. Lees, c/o Canadian General Electric Co., 755 Division St., North Cobourg, Ontario, Canada.

November 18—Blow Molding, Newark Section; Essex House, Newark, N. J. Chairman: Robert Hoehn, Mack Molding Co., Ryerson Ave., Wayne, N. J.

1961 RETECS

April 25, Indianapolis, Ind., Central Indiana Section; **Plastics for Tooling.** Section President: Milton Brummer, 4241 Marrison Place, Indianapolis, Ind.

May 9, Detroit, Mich., Detroit Section; **Plastics in the Automotive Industry.** Section President: John D. Young, E. I. du Pont de Nemours & Co., Inc., 13000 West Seven Mile Rd., Detroit 35, Mich.

October, Niagara Falls, N. Y., Buffalo Section; **Foams.** Section President: William Dunmeyer, Carborundum Co., Buffalo Ave., Niagara Falls, N. Y.

Offers of papers for presentation at these Regional Technical Conferences are invited. Please address offers to Section Presidents, as indicated above.

SPI CONFERENCE

October 13, 14—Sixteenth Annual SPI New England Section Conference, The Society of the Plastics Industry, Inc., Wentworth-by-the-Sea, Portsmouth, N.H.

SPI EVENTS—1960

October 23, 24, 25—Fluorocarbons Division Meeting, Sponsored by the Society of the Plastics Industry, Inc., Edgewater Hotel, Chicago, Ill.

SPI EVENTS—1961

February 7, 8, 9—Sixteenth Reinforced Plastics Division Conference, The Society of the Plastics Industry, Inc., Edgewater Beach Hotel, Chicago, Ill.

April 20, 21—Eighteenth Annual SPI Western Section Conference, The Society of the Plastics Industry, Inc., Hotel del Coronado, Coronado, Calif.

June 5-9—Ninth National Plastics Exposition, Sponsored by The Society of the Plastics Industry, Inc., Coliseum, New York City.

June 5-9—SPI National Conference, Sponsored by The Society of the Plastics Industry, Inc., Commodore Hotel, New York City.

CONGRESS FOR MACROPLASTICS

The International Congress for Macroplastics will be held on **October 17-19, 1960,** Utrecht, Netherlands.

POLYMER SYMPOSIUM

July 27-August 1, 1961, International Symposium on Macromolecular Chemistry, Montreal, Canada. Address inquiries to: The Organizing Committee International Symposium on Macromolecular Chemistry, P.O. Box 816, Sarnia, Ontario, Canada.

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SECTION NEWS

Baltimore-Washington

Memorial Established

The Baltimore-Washington Section of SPE has established an award dedicated to the memory of one of its most beloved members, Nancy Rucker. The Nancy Rucker Memorial Award is based on the recognition of the achievements and potential leadership of members of the Society, who by diligence and above-average effort have made significant contributions to local or international activities of SPE. The Award will be in the form of an engraved certificate and will be presented at a dinner sponsored by the Society. The B-W Section will at such time as the income of funds is of sufficient size, establish a scholarship for a promising student who has elected to follow the profession of plastics science or engineering. This shall be known as the Nancy Rucker Memorial Scholarship.

Golden Gate

Plastics Scrap

W. J. HILL

June 16, approximately 50 members of the Golden Gate Section assembled at the International Inn to hear Mr. J. B. Nusbaum of Western Plastics and Rubber Co. discuss the subject "Plastic Scrap and its Utilization". Mr. Nusbaum analyzed the thermoplastic scrap business from the standpoint of the molder, the scrap reprocessor and the scrap dealer. He broke the field down into its divisions as determined by type of thermoplastic, i.e., cellulosic, styrene and styrene derivatives, acrylics and so forth; and, also as to sources of scrap and the various means of collection, segregation and cleaning necessary for proper reprocessing. In addition he went, with some detail, into the economic factors of the scrap business, its seasonal variations and the effects of the price of virgin and off grade resin prices on the price of reprocessed scrap.

The second portion of Mr. Nusbaum's talk was on the various means used in reprocessing thermoplastic scrap such as two roll mills, compounding extruders and Banburys with particular reference to how end use of the scrap would determine method and type of processing.

Kansas City

Extension Course Sponsored

DONALD C. CRAWFORD

Kansas City University has accepted the offer of this Section to sponsor an extension course on the fundamentals of plastics technology. The course will be held from 7:30 to 9:30 each Wednesday evening during the Fall semester for a period of 12 weeks. The following men will deliver lectures: Bill Bower (Bendix), Bill Short (Hallmark), and Don Crawford (Spencer).

Western New England

Meetings Calendar Announced

ROBERT W. SHERMAN

Meetings for this Section are scheduled as follows:

September 7, 1960—A Forward Look at Plastics, Hiram McCann, Editor, Modern Plastics Magazine.

October 5, 1960—Processable Teflon, W. Bass Watkins, and Filled, Chemically Cross-Linked Polyethylene, W. F. Abbey.

November 2, 1960—Plastics in Home Furnishings, Mrs. Vera Berry Hahn, Fashion Editor, Home Furnishings Daily.

December—Christmas party.

February 1 ,1961—Pecision Molded Plastic Parts, Richard M. Bell, President, Lakeview Precision Molding Inc.

March 1, 1961—Plastics in Power Tools, Len Pratt, Millers Falls Tool Co., and Reinforced Plastics Application, E. Leslie Goodwin, President, Cape Cod Shipbuilding

January 4, 1961—Blow Molding Processes, Techniques, and Applications, Herbert Samuels, Union Carbide Chemicals Co.

April—Regional Technical Conference

May 3, 1961—Urethane, B. Collins, Nopco Chemical Co., and Expanded Polystyrene and it Applications, Horace Gooch, Treasurer, Worcester Molded Plastics

SOCIETY ACTION

(Continued from page 1154)

Eastern New England Section is maintaining close liaison with Lowell Technological Institute where it was instrumental in initiating the undergraduate courses leading to Bachelor of Science in Plastics Technology. ENE Section sponsors SPE's first Student Chapter at Lowell Tech. as well as a scholarship for one of its students.

Chicago Section was one of the first SPE Sections to sponsor an annual scholarship for a deserving student.

A survey of polymer courses offered in over 100 universities has just been completed by our Committee. The survey report will be in a future issue of the SPE Journal. To promote plastics engineering education, results are being publicized widely in SPE and the industry.

The first brochure "Careers in Plastics Engineering", developed by our Committee with the assistance of the SPE Membership Committee and its Student Membership Sub-Committee, will be completed this fall. Its purpose is to interest high school and college students in choosing plastics science and engineering as a career. The Committee plans distributing this career brochure among students and career advisors in high schools and among colleges and universities, SPE members and Sections. A limited number of copies are available to SPE members upon request to the Executive Office.

If the student is interested, he will fill out and mail a coupon enclosed in the brochure requesting further information. He will then be sent a second brochure "Program for Engineering Education in Plastics" and an SPE Membership Brochure, an up-to-date revision of the brochure of this title published five years ago by the Education Committee.

Our Committee will wind up its year's activity by again sponsoring an Education Luncheon on Tuesday, January 24, at the SPE 17th ANTEC at the Shoreham, Washington, D. C. An outstanding figure in scientific and engineering education will be the luncheon speaker. Every SPE member and guest attending ANTEC is cordially invited to attend.

—■—

edited by
Thomas A. Bissell,
SPE Executive Secretary

NEW BOOKS

POLYMERS AND RESINS; THEIR CHEMISTRY AND CHEMICAL ENGINEERING

Brage Golding, Ph.D. (D. Van Nostrand & Company, Inc. Princeton, N. J., 1959, 744 pp., $15.00)

This comprehensive book is a thorough study of the chemistry, properties, manufacture, fabrication and applications of all polymers and resins including fibers and elastomers. It is divided into 12 chapters, with emphasis on technology, which makes it most valuable to plastic engineers. Starting with natural products and their modified derivatives the author continues with synthetic condensation products, addition products and describes the different methods of fabricating and processing.

The last chapter gives the various applications of fibers, plastics and elastomers. There is a subject index and a name index, and a great many diagrams, sketches and excellent photographs which make reading this book most pleasant.

The Author displays a tremendous amount of knowledge and should be commended for the work required to make this manual very complete and up to date. We believe everyone connected with plastics engineering, manufacturing, fabricating and finishing should have a copy either on his desk or in the laboratory.

Dr. Louis C. Barail,
Barail Associates

RUSSIAN FOR THE SCIENTIST

John Turkevitch, Ph.D. and Ludmilla B. Turkevitch, Ph.D. (D. Van Nostrand Company, Inc., Princeton, N. J. 1959, 255 pp., $5.95)

In the preface, the authors write: "This book is designed for the English-speaking scientist. Its aim is to furnish this scientist with a tool with which he may go to Russian scientific literature and extract the particular information that he seeks, be it a mere deciphering of titles, a reading of graphs, or a thorough study of articles. . . . . Our idea is to exploit what the scientist already knows, his English terminology; then, as we initiate him into noun, adjective and verb construction, we will show him how to recognize scientific cognates, of which there are many in Russian."

We can state that they succeeded to the point of making Russian attractive, and this is not a small achievement. Those who, like ourselves, have tried, because of the necessities of the present times, to learn even the fundamentals of this difficult tongue and have either been discouraged or merely failed will be able to try again, thanks to these Princeton University linguists.

The book is divided into 20 lessons, starting with the complicated alphabet, continuing with nouns, pronouns, cases, verbs, prepositions, adjectives, numerals, time, prefixes and suffixes.

There are also exercises in each lesson and this makes using this book even easier. If you read the first two lessons just for fun, then the similarity of a great many English and Russian scientific words will entice you, as it did us, to enjoy this excellent manual.

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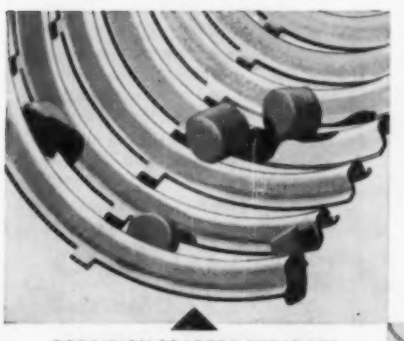

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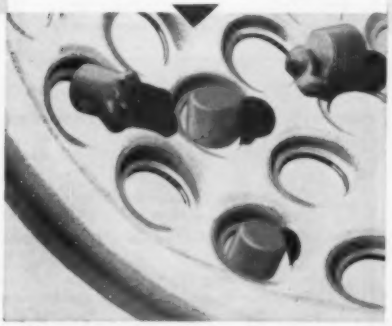

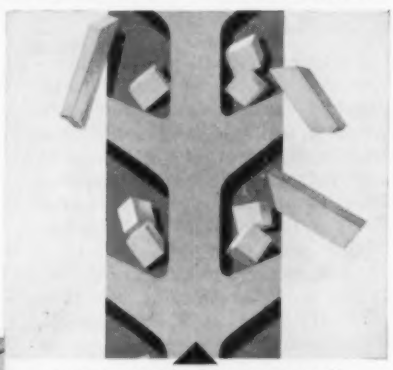

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Employment & Service Guide

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Minimum of five years experience and demonstrative creativity. This is an outstanding growth opportunity with an expanding manufacturer with an excellent benefit program.

Personal interview will be arranged.

Send resume to: Mr. Jack Bloch, Director of Design & Development, Loma Industries, Inc., 3000 W. Pafford Street, Forth Worth, Texas.

PLASTICS ENGINEER

To manage small plastics operation of southern machinery manufacturer. Processes include compression and injection moulding of plastic and synthetic components. Several years experience is needed. Must be able to originate practical designs to function on machines. Please send complete details of specific background for immediate reply. Age: 30-40. Box No. 8960, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

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Sandia Corporation, located in Albuquerque, N. M., is engaged in research and development of nuclear weapons and other projects for the AEC. Albuquerque is a modern city of about 225,000; has an excellent climate and many cultural and recreational attractions. Winters are mild, summer nights are cool, and there's plenty of year-around sunshine. Liberal employee benefits include generous vacations, retirement and insurance plans and an educational assistance program. Paid relocation allowance.

Mail resume in complete confidence to: Professional Employment Section 527.

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Educational requirements include a B.S. or M.S. in chemistry with emphasis on organic.

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Please send resume stating age, education, experience and salary requirements to:

General Employment Manager

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Specialist in developing process equipment and machinery for production of extruded plastic sheeting.

Position requires ME or Ch E degree or equivalent and three or more years' experience in related Manufacturing Process Development, Facility Engineering, or Operations. Background in equipment design desirable. Involves close cooperation with Design, Research & Development, and Production people.

Please send resume including present earnings and salary requirements in confidence to:

Mr. W. R. Marks
Coordinator of Professional Employment

ANSCO
Division of General Aniline & Film Corp.
Binghamton, New York

FINISHING SUPERVISOR & PROCESS ENGINEER

Plastic manufacturing company in Western Michigan with outstanding reputation in the plastic field and demonstrated yearly growth has openings for two high-caliber finishing foremen and a finishing process engineer. Applicants should have experience in decorative finishing of plastics, involving vacuum metalizing, silk screening, painting, hot stamping and assembly. Foremen should have demonstrated supervisory ability. Earnings in excess of $7,000.00, liberal vacation policy and insurance program. Moving expenses paid. Excellent area in which to live, work, play and raise a family.

Write to: Michigan Plastic Products, Inc.
Robbins Road
Grand Haven, Michigan
Attention: Mr. Charles Maitzen

MECHANICAL OR CHEMICAL ENGINEER

Mechanical or Chemical Engineer for injection molding technical service and development. Desire experience in mold design, material selection and injection molding techniques and equipment. Please send resume, including education, experience, and salary requirements to Box No. 8060, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

PRODUCT SALES ENGINEER

Plastic Extruding

Long established East Coast leading designer and manufacturer of rubber and plastics extruders will add a sales engineer to solicit and handle proposals, advise customers on problem solutions and co-ordinate application engineering on wide variety of extruding equipment.

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Last day for inserting ads is the first day of the month preceding date of publication.

Employers please note:
The SPE Journal does not have resumes on file. These must be requested from the applicant.

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for Career in Technical Writing and Editorial Work

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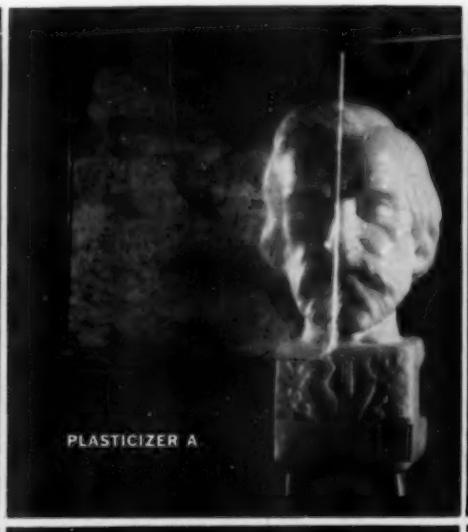

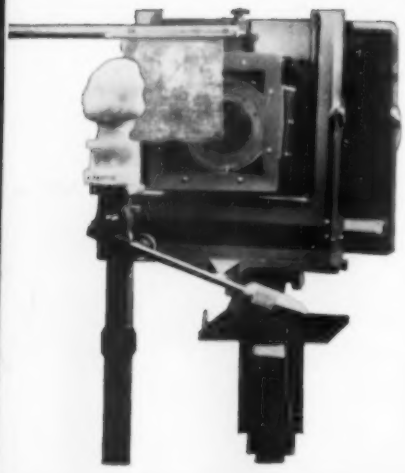

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